INSTITIÚID ARD-LÉINN BHAILE ÁTHA CLIATH
(Dublin Institute for Advanced Studies)

ANNUAL REPORT
1996

P.N. 5789

Institiúid Ard-Léinn Bhaile Átha Cliath
Dublin Institute for Advanced Studies

Annual Report of the work of the
Institute and its Constituent Schools
presented by the Council to the
Minister for Education in respect of
the year ended 31 December 1996

P.N. 5789

Summary of the Annual Report of the Work of the Constituent Schools for the year ended 31 December 1996

School of Celtic Studies

The Board for the 1995-2000 quinquennium was appointed in late 1995 and first met on 1 February 1996. The year thereafter was characterized primarily by the new Board's review of the School's activities.

During the period, the staff was reduced by four through the retirement in July of Proinsias Mac Cana, the resignations in August of Máirín Ní Dhonnchadha and Seán Ua Súilleabháin, and of Órla McMorrow in December. The complement of Research Scholars, appointed for a year from 1 October, comprised four from Ireland, two from Germany, one from Canada, and one from the United States.

Projects on a number of aspects of manuscript cataloguing were actively continued; Fasc. xiii of the National Library catalogue was completed by Pádraig Ó Macháin and published by the School. Staff had a significant range of scholarly work published by other institutions.

School of Theoretical Physics

Forty-one research workers from the universities or other institutes of research or higher education (mainly in Ireland) were admitted as Research Associates of the School; forty-three scientists from abroad visited the School during the year.

Mathematical symposia were held at Easter and at Christmas; twenty-eight seminars were held at DIAS and joint seminars with other third level institutions took place. Members of the School gave eleven lectures in Ireland. The statutory public lecture was given at Trinity College by Professor M. Keane (CWI Amsterdam).

The primary areas of research were theoretical particle physics, statistical mechanics and applied probability theory; members of the School published papers in scientific journals and conference proceedings; they participated in sixty-nine conferences abroad.

School of Cosmic Physics.

It was an extremely busy year for the ***Geophysics Section***. The COMBO project, a controlled-source study of the Earth's core-mantle boundary, produced two studies of the zone just above that boundary under the Pacific. These questioned some current beliefs about the zone and offered a model which contained velocity variations rather than boundary topography. Stations were mobilized in Portugal but the main COMBO shots were again prevented from taking place and that part of the programme is indefinitely delayed. Other sources were recorded instead. The VARNET project, the biggest onshore seismic profiling study ever carried out in these islands, took place in SW Ireland in June and was very successful. Work is now underway to elucidate both the Variscan Front and the Iapetus Suture Zone. The Section coordinated the field work. Further gravity measurements were also carried out in the same area. The third major project was AIRS which used side-scan sonar to map and image 200,000 square kilometres of the Atlantic Ocean floor to the west of Ireland. These data will be used by the Section and UCD to study large-scale geophysical and geological patterns in a particularly interesting area. This work correlates well with the previous RAPIDS project, which studied deeper structures.

During 1996 the renewals in Dunsink concerning scientific programmes, research facilities and infrastructure established a suitable working environment for carrying out research in the ***Astronomy Section***. An important stimulus was the start of a European TMR Postdoctoral position to study high-energy aspects of strong star formation in extragalactic settings. Two research students had started just before that, one of which completed the first thesis (MSc) under the current Directorship. The subject of this work was the development of a mathematical technique and subsequent application to X-ray observations and to the large-scale distribution of galaxies. Overall, the contours of a thematic division of the research into a few distinct areas became more apparent (viz. active galactic nuclei, extragalactic star formation, galaxy clusters, large-scale structure), all of which refer to topical areas of current research. The development of the detector for the Optical Monitoring Camera on the INTEGRAL spacecraft progressed considerably, while the OMC consortium was strengthened when eventually British participation was secured. The upgraded visitors' facility at Dunsink was developed to near-completion over the year.

In recognition of the broader range of research now being performed it was decided in 1996 to change the name of the ***Cosmic Ray Section*** to ***Astrophysics Section***. Although much cosmic ray related work continues to be performed, both experimental (the continuing analysis of data from the UHCRE), environmental (IRMA dosimetry) and theoretical (a new dust sputtering model for the cosmic ray composition) there is also increasing work in other areas of Galactic astrophysics, especially phenomena associated with star formation and associated outflows. Of particular interest was the first observational confirmation of strong extended magnetic fields in protostellar outflows. Numerical simulation is a key tool in understanding astrophysical phenomena and it is expected that this, along with theoretical and computational plasma physics, will be strong growth areas in coming years.

Annual Report of the work of the Institute and its Constituent Schools presented by the Council for the year ended 31 December 1996.

In accordance with the provisions of Section 29 of the Institute for Advanced Studies Act, 1940 (No. 13 of 1940), the Council of the Institute has the honour to present to the Minister for Education for submission to the Government a report for the year ended 31 December 1996.

The report is presented under the following principal heads:-

I. Constitution of the Council of the Institute and of the Governing Boards of the three Constituent Schools on the 31 December 1996.

II. Administrative Staff of the Institute.

III. Report of the Governing Board of the School of Celtic Studies.

IV. Report of the Governing Board of the School of Theoretical Physics.

V. Report of the Governing Board of the School of Cosmic Physics.

I. Constitution of the Council of the Institute and of the Governing Boards of the three Constituent Schools on the 31 December 1996.

The Council of the Institute

Chairman

D. Donnelly, D.Sc., Ph.D., M.R.I.A., F.I.C.I., C.Chem., F.R.I.C.

Ex-Officio Members

A. Cosgrove, B.A., Ph.D., President, University College, Dublin; M. Herity, President, Royal Irish Acad-emy, M.E., Ph.D. (Leeds), D.Sc. F.I.E.E., F.I.M.A., F.I.E.E.E., F.I.E.I., M.R.I.A.; T. N. Mitchell, M.A., Ph.D., Litt.D., L.L.D., D.Hum.L., F.R.C.P.I.(Hon.), Hon. F.R.C.S.I., M.R.I.A., Provost, Trinity College, Dublin.

Members Appointed by the Governing Boards of Constituent Schools

A.W.B. Jacob, M.A., M.Sc., Ph.D.; A. Khan, B.Sc., Ph.D.; J. T. Lewis, B.Sc., Ph.D.; C. Morawetz B.A., M.S., Ph.D.; B. Ó Madagáin, B.A., Ph.D., M.R.I.A.; M. Ó Murchú, M.A. (Dubl.NUI), Ph.D., M.R.I.A.

Governing Board of the School of Celtic Studies

Chairman

B. Ó Madagáin, B.A., Ph.D., M.R.I.A.

Senior Professors

P. Mac Cana, M.A., Ph.D., M.R.I.A.; M. Ó Murchú, M.A.(Dubl.NUI), Ph.D., M.R.I.A.

Appointed Members

A. Harrison, M.A., Ph.D; M Ní Bhrolcháin, M.A., Ph.D.; M. P. Ní Chatháin, M.A., Ph.D.; M. Ní Neachtain, M.A., H. Dip.; C. Ó Gráda, M.A., Ph.D., Dip. European Studies; Ú. Uí Bheirn, M.A., Ph.D.

Governing Board of the School of Theoretical Physics

Chairman

C. Morawetz, B.A., M.S., Ph.D.

Senior Professors

J. T. Lewis, B.Sc., Ph.D.; L. O' Raifeartaigh, M.Sc., Ph.D.

Appointed Members

A.C. Breslin, B.Sc., M.Sc., Ph.D.; J. Browne, B.E., M.Eng.Sc., Ph.D., D.Sc., F.I.E.I.; J.C.I. Dooge, M.E., M.Sc., C.Eng., F.I.E.I., F.A.S.C.E., D.Agr.Sc.; B. Finnucane, B.Sc., Ph.D.; N. Marshall, B.Comm., A.C.A.; A. Montwill, M.Sc., Ph.D. D.Sc.; W. Reville, B.Sc., Ph.D.; T. D. Spearman, M.A., Ph.D. (Cantab), M.R.I.A., Member Academia Europaea, F.T.C.D.

Governing Board of the School of Cosmic Physics

Chairman

A. Khan, B.Sc., Ph.D.

Senior Professors

L. O'C. Drury, B.A., Ph.D.; A.W.B. Jacob, M.A., M.Sc., Ph.D.; E.J. A. Meurs, B.Sc., M.Sc., Ph.D.

Appointed Members

P. K. Carroll, M.Sc., D.Sc., Ph.D., F.Inst.P., M.R.I.A.; B. Harvey, M.A., H.D.E., F. Bis.; M.T. Lago, M.Sc., Ph.D.; M. F. Mulcahy, M.Sc., Ph.D.; M. O'Connor, F.C.C.A, B.L., Dip. in Bus. Studies; H. Sheehan, B.S., M.A., Ph.D.

II. Administrative Staff of the Institute

Registrar

John Duggan, B.Sc.

Executive Officer

Mary Burke, B.A., Grad. IPD.

Finance Officer

Eamonn Harrigan, B.Comm., H.Dip.Ed., A.C.M.A.

Assistant Finance Officer

Angela Stubbs.

Clerks

Noreen Granahan; Helena Moynihan; Tony Broderick; Eibhlín Nic Dhonncha.

Annual report of the Governing Board of the School of Celtic Studies for the year ending 31 December 1996 adopted at its meeting of 22 May 1997

Contents

1 Staff, Research Scholars, Research Associates

1.1 Staff

Rolf Baumgarten (Professor; special responsibility for bibliography, and director of promotion)

Pádraig de Brún (Professor; special responsibility for manuscript studies, and director of publishing)

Fergus Kelly (Professor; special responsibility for Early Irish law texts, and director of events)

Proinsias Mac Cana (Senior Professor; special responsibility for Early Irish, Welsh, and Breton; to 7 July 1996, retired)

Malachy McKenna (Assistant Professor; spoken language studies)

Órla McMorrow (Secretary of the School)

Máirín Ní Dhonnchadha (Chief Editor; also Irish textual and literary studies; to 31 August 1996, resigned to take up a professorship at University College Galway)

Aoibheann Nic Dhonnchadha (Assistant Professor; manuscript studies and Irish medical texts)

Siobhán Ní Laoire (Academic Librarian; also textual and sociolinguistic studies)

Pádraig Ó Macháin (Assistant Professor; manuscript studies and bardic verse)

Máirtín Ó Murchú (Senior Professor; Director of the School; special responsibility for spoken language studies)

Michelle O Riordan (Publications Officer; also historical studies)

Seán Ua Súilleabháin (Research Assistant; lexicography; to 31 August 1996, resigned to take up a lectureship at University College Cork)

Emma Ryan (Publications Secretary)

1.2 Non-establishment staff

Eunice Delaney (Assistant Librarian)

Grace Toland (Library cataloguing; part-time)

1.3 Research Scholars

Brian Ó Curnáin

Brian Ó Catháin

Dorothee Tratnik

Petra Sabine Hellmuth

Thomas O'Loughlin

Peter Smith / Peadar Mac Gabhann (to 30 April 1996)

Karen Jankulak (from 1 October 1996)

Antain Mac Lochlainn (1–31 October 1996)

Mary A. Valante (from 1 October 1996)

1.4 Visiting Senior Professor

Professor Donnchadh Ó Corráin (University College, Cork)

1.5 Professores Emeriti

Brian Ó Cuív

Proinsias Mac Cana (from 8 July 1996)

1.6 Research Associates

(year of first appointment)

Dr Gwenllian Awbery, University of Wales, Cardiff (1990)

Dr John Carey, Harvard University (1990)

Dr Thomas Charles-Edwards, University of Oxford (1990)

Professor Toshio Doi, Nagoya Women's University (1991)

Dr David N. Dumville, University of Cambridge (1989)

Professor D. Ellis Evans, University of Oxford (1990)

Professor D. Simon Evans, St David's University College, Lampeter (1992)

Professor William Gillies, University of Edinburgh (1989)

Professor Geraint Gruffydd, Centre for Advanced Welsh and Celtic Studies, Aberystwyth (1989)

Professor Eric P. Hamp, University of Chicago (1989)

Professor Michael Lapidge, University of Cambridge (1988)

Professor Donald MacAulay, University of Glasgow (1989)

Professor Toshitsugu Matsuoka, Hosei University, Tokyo (1991)

Dr Martin McNamara, MSC, Milltown Institute of Theology and Philosophy (1989)

Professor Tomás Ó Concheanainn, University College, Dublin (1991)

Professor Donnchadh Ó Corráin, University College, Cork (1991)

Dr Pádraig Ó Néill, The University of North Carolina at Chapel Hill (1990)

Dr Brinley F. Roberts, National Library of Wales, Aberystwyth (1990)

Professor R. Mark Scowcroft, Catholic University of America (1990)

Dr Richard Sharpe, University of Oxford (1988)

Professor Robert L. Thomson, University of Leeds (1991)

Professor Calvert Watkins, Harvard University (1990)

Professor T. Arwyn Watkins, University College, Dublin (1989)

1.7 Visiting Scholars

(Only overseas scholars who availed of library and research facilities are included in the following list. In addition to these, the School accords library and research facilities to Irish-based scholars when it holds materials which are lacking in the scholars' own institutions and in the major libraries in Dublin.)

Jacqueline Borsje (Free University of Amsterdam)
Melita Cataldi (University of Turin)
Ann Dooley (University of Toronto)
Aidan Doyle (Lublin)
David Dumville (Cambridge)
Eric P. Hamp (Chicago)
John Higgins (Connecticut)
Karen Jankulak (Toronto)
Rolf Kõdderitzsch (Bonn)
Frederik Kortlandt (Leiden)
Antoinette Madden (UNESCO, Paris)
Ursula Marmé (Bonn)
Toshi Matsuoka (Tokyo)
Seamus McElwain (Tokyo)
Tatyana Mihailova (Moscow)
Setsuoko Mori (Tokyo)
Séamas Ó Direáin (Marymount College, California)
Roibeard Ó Maolalaigh (Edinburgh)
Elias Roma (Pavia)
Peter Schrijver (Leiden)
Stefan Schumacher (Halle–Wittenberg)
Peter Smith (Bonn)
Nathalie Stalmans (Brussels)
L. C. Hildegard Tristram (Freiburg)
Maria Tymoczko (Massachusetts)
Jonathan Wooding (Sydney)

2 Research

During 1996 research for publication continued in the fields of manuscript studies, medical texts, Early Irish law, Early Modern Irish verse, lexicography, dialect studies, bibliography. In addition to projects being conducted internally, there is editorial supervision of work submitted by outside scholars in a number of fields for which the School has statutory responsibility (see below).

2.1 Projects

Pádraig de Brún continued work on the second edition of volume III of the *Catalogue of Irish manuscripts in the British Museum*, and on indexes (with Pádraig Ó Macháin and Toshi Matsuoka) for

the proposed reprint of *Irish grammatical tracts* (ed. O. Bergin). He did editorial/supervisory work on the *Catalogue of Irish manuscripts in the Falvey Memorial Library, Villanova University, Pennsylvania* (W. J. Mahon); and on *Clár lámhscríbhinní Gaeilge Choláiste Ollscoile Chorcaí: cnuasach an Phaoraigh agus cnuasaigh eile* (B. Ó Conchúir). The *Catalogue of Irish manuscripts in the National Library of Ireland*, fasc. 13 (Pádraig Ó Macháin and Nessa Ní Shéaghdha) was seen through the press. He continued editorial/typesetting work on vol. I of the *Survey of the Gaelic dialects of Scotland* (ed. Cathair Ó Dochartaigh). He prepared for publication his *Scriptural instruction in the vernacular: the Irish Society and its teachers, 1818–1827.*

Pádraig Ó Macháin continued research on *The catalogue of Irish manuscripts in the National Library of Ireland.*

Aoibheann Nic Dhonnchadha continued work on cataloguing medical manuscripts in Trinity College Dublin, and research on Early Modern Irish medical texts.

Brian Ó Cuív continued work on the catalogue of Irish manuscripts in the Bodleian Library, Oxford; he examined additional items and recorded the draft descriptions of 56 manuscripts on computer disk.

Proinsias Mac Cana continued research on the history of Welsh and Insular Celtic syntax and Irish literary topics. He did editorial work on *Gereint uab Erbin* (ed. R. L. Thomson).

Fergus Kelly completed his monograph on *Early Irish farming: the evidence of the law-texts*; he is preparing an edition of the *Old Irish legal heptads.*

Siobhán Ní Laoire continued research on aspects of stylistic variation and register in Modern Irish.

Máirín Ní Dhonnchadha continued research on *Cáin Adomnáin* and on women's history. She continued editorial work on *Celtica* 23.

Malachy McKenna continued work on the edition of *The spiritual rose.*

Seán Ua Súilleabháin continued work on the edition of Risdeard Pluincéad's Latin–Irish dictionary (1662); he continued work on an edition and Irish index of Ó Maolchonaire's Latin–Irish dictionary.

Bibliographical work was continued by Rolf Baumgarten on the (database) *Bibliography of Irish linguistics and literature*; he made a visually projected presentation on this matter to the Governing Board. He continued research on Early Irish syntax and textual cruces. He did editorial work on *Studies in Welsh word formation* (Stefan Zimmer).

2.2 Research Scholars' work

Peter Smith / Peadar Mac Gabhann completed and submitted his D.Phil. thesis (Oxford) 'A critical edition of three poems ascribed to Gilla Coemáin'.

Brian Ó Curnáin completed his Ph.D. thesis on 'Gnéithe de Ghaeilge Chonamara'.

Dorothee Tratnik continued her project on 'A comparative study of the vocabulary of the dialects of Munster'; she carried out fieldwork in Cúil Aodha / Baile Bhúirne (Co. Cork) and Ballyferriter / Dún Chaoin (Co. Kerry).

Petra Sabine Hellmuth continued work on an edition and critical analysis of *Aided Chon Roí.*

Karen Jankulak continued research on medieval ecclesiastical and religious history, specifically through the cults of saints, in Brittany, Cornwall, and Ireland.

Mary A. Valante continued research on 'The impact of Scandinavian settlement on the Irish economy'.

3 Publishing

As one of its statutory functions, in addition to research and publication by its own staff, the School provides for the assessment, editing, and publishing of books and papers by outside scholars.
Computerised editing for publication and typesetting was directed by Pádraig de Brún and Michelle O Riordan, assisted by Emma Ryan. Computer consultant was Dr W. G. Sullivan of University College, Dublin. Book design was under the expert guidance of Professor Bill Bolger of the National College of Art and Design.

The following items were published in 1996:

- *Catalogue of Irish manuscripts in the National Library of Ireland.* Fasc. xiii: G 700 – G 773. By Pádraig Ó Macháin and † Nessa Ní Shéaghdha. 1996. 130 pp. ISBN 18500–177–2. ISSN 0791–1890. Ir£10.

  Manuscripts mainly of the nineteenth century, including *Eochairsgiath an Aifrinn* (G 707), *Smaointe beatha Chríost* (? 18th c.; 713), *Scáthán shacramuinte na hAithridhe* (? 18th c.; 729), Poems of Raftery (751), Robert McAdam papers (702), Traditions from Tuam district (754, 755, 756, 769), etc.

- *Scéala Scoil an Léinn Cheiltigh : Newsletter of the School of Celtic Studies*, ed. Rolf Baumgarten. No. 9, November 1996. 40 pp. ISSN 0790–9853. Free.

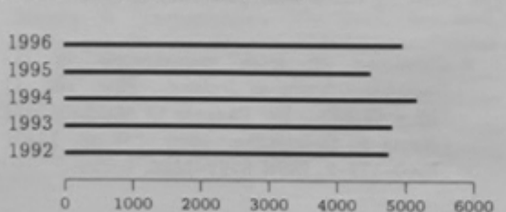
  Contains inter alia essays by Dr Neil Buttimer (University College, Cork) 'French method and Irish discourse', and by Professor David N. Dumville (University of Cambridge) '*Corpus genealogiarum Hiberniae*', a contribution to 'Phonetic texts', the series of samples of living Celtic speech, by Dr Dónall Ó Baoill (Institiúid Teangeolaíochta Éireann), entitled 'The dialects of north-west Donegal', and 'Irish studies theses 1995' by the Editor.

The following publications of the School were reprinted:
Annála Connacht (A. Martin Freeman; Catalogue no. G 2).

4 Booksales

The classified and annotated catalogue of the School of Celtic Studies publications from its beginning was updated and distributed.
Promotion of publications was through advertising in *Books Ireland*, *Comhar*, *An Saol*, *Slógadh*, etc.

The number of books sold during 1996 was 4978. This figure was calculated from end-of-year stock-taking figures after appropriate deduction of additions etc. during the year. The comparable figures for the preceding years were 4508 for 1995, 5175 for 1994, 4818 for 1993, 4755 for 1992. The ca. 900 copies of the *Newsletter* that have since 1987 been annually distributed world-wide have not been taken into consideration. The following chart is a projection of the above figures.



5 Library

Current cataloguing continued using the automated library management system and a long term programme of retrospective cataloguing in particular subject areas was initiated. An Online Public Access Catalogue was made available in the library thus making all records searchable as soon as they are inputted. A major reorganisation of the pamphlet and offprint collection was undertaken but the outcome of the project was marred by acute storage problems–the collection was made virtually inaccessible to users due to its location in the basement from January to December 1996. Regular updates on recent accessions and current periodicals were issued and research and bibliographic queries, from members of the School and visitors alike, were dealt with. Acquisitions continued in subject areas relevant to the research need of the School. A report on developments in the Library since January 1991 was presented to the Governing Board of the School by Siobhán Ní Laoire (Academic Librarian) in March.

6 Events

6.1 Lectures

- The Statutory Public Lecture for the year 1996 was delivered by David Howlett (Oxford) on 29 November 1996, at University College, Dublin, entitled '*Scotti ludentes*, the Irish at play in their earliest letters'.

6.2 Annual Symposium/Tionól 1996

The Annual Symposium/Tionól was held on 29–30 November, incorporating as a key feature the Statutory Public Lecture (see above). In addition, the following papers were read:

- Anthony Harvey (Royal Irish Academy): 'Problems in dating the origin of the Ogham script'.
- Malachy McKenna (Scoil an Léinn Cheiltigh): 'Caolú agus na liopaigh i nGaeilge Thorr, Co. Dhún na nGall'.
- Úna Nic Éinrí (Coláiste Mhuire gan Smál, Luimneach): 'Tadhg Gaelach Ó Súilleabháin: file Triontach Barócach'.
- Fergus Kelly (School of Celtic Studies): 'The edition of Old Irish law-texts and wisdom-texts: aiming for consistency'.
- Art Hughes (Queen's University, Belfast): 'On the exploitation of "dual nationality" by Gaelic poets and patrons in seventeenth-century Ulster'.

- Tom O'Loughlin (School of Celtic Studies): 'Rheinau 73 (Zürich) as a witness to the use of Hiberno-Latin materials in the eighth century'.

- Ailbhe Ó Corráin (University of Ulster, Coleraine): 'On the cognitive basis of certain grammatical categories in Irish'.

7 Outside activities and contributions to scholarship

7.1 Activities

Lectures were delivered by:
Proinsias Mac Cana, 'Mythologie et littérature irlandaises', University of Brest (March); 'The Irish analogues of the Mélusine legend', International Symposium 'Islanders and Water-dwellers', Department of Irish folklore, University College Dublin (June); 'Drinking vessels in medieval Irish literature', International Medieval Conference, University of Leeds (July).

Fergus Kelly 'The early Irish Church', Belvedere College (October).

Seán Ua Súilleabháin, 'Osborn Bergin', Léachtaí Cholm Cille, Maynooth (March); a lecture on the life and songs of Mícheál Ó Tuama, in Clondrohid, Co. Cork (July).

Siobhán Ní Laoire 'Stíleanna cainte agus caidreamh sóisialta: *Baile an Droichid* agus an saol mór', Parlaimint na mBan (February).

Malachy McKenna 'Caolú agus na liopaigh i nGaeilge Thorr, Co. Dhún na nGall', 'Teangeolaíocht na Gaeilge', Coláiste Phádraig, Má Nuad; he gave an M.Phil. course on 'Phonology and morphology', Center for Language and Communication Studies, Trinity College, Dublin.

Máirín Ní Dhonnchadha 'The poet, the lord, and the *spéirbhean*: some considerations of space and gender in Gaelic literature', Department of Celtic, Harvard University (April); 'Female authors and feminine perspectives: two medieval Irish texts reconsidered', 18th Annual University of California Celtic Studies Conference, UCLA (April).

Lectures by Research Scholars:
Brian Ó Catháin 'Joe Mháirtín Ó Flaithearta—ríscéalaí Inis Oírr', Éigse Choláiste na Tríonóide (February); 'Modhanna eagarthóireachta ar ábhar béaloidis', Coláiste Phádraig, Maigh Nuad (March); 'Gaeilge Inis Oírr', ibid.

Mary A. Valante 'G.I.S. and the Irish annals', 31st International Congress on Medieval Studies, Kalamazoo, Michigan (May)

Thomas O'Loughlin 'Manuscripts and society in early Christianity: the use of the Didache', Irish Biblical Association (March); 'The importance of Vetus Latina variants in understanding the development of liturgical texts prior to the formation of written texts: the case of Pater Noster', Irish Biblical Association AGM (April); 'Religion as a factor in cultural identity in early medieval Ireland: the case of the cult of Patrick', Annual Colloquium of the Combined Departments of Theology and Religious Studies of the Federal University of Wales (June); 'The sectioning of the text of Genesis as a tool in locating the origin of manuscripts in the early middle ages', Irish Conference of Medievalists, Maynooth (June); 'The Christology of Isidore of Seville as exemplified in his exegesis of Genesis', Third Patristic Symposium, Maynooth (October); 'Reconstructing medieval pilgrimage route from medieval maps', Department of Theology and Religious Studies, University of Wales, Lampeter (November); 'The role of authorial anonymity in early medieval theological texts', Department of Religious Studies, University of Wales, Cardiff; 'The problematic of reconstructing the intellectual community that produced the Didache', The Studium Generale of the Dominicans at Tallaght (December).

7.2 Scholarly publications

Proinsias Mac Cana and Rolf Baumgarten co-edited *Ériu* volume 47, to which the former contributed (with Dónall Ó Baoill) 'On the extended use of *ag* before verbal nouns'. Proinsias Mac Cana also published 'Y canu mawl yn Iwerddon cyn y Normaniaid', *Beirdd a Thywysogion: barddoniaeth llys yng Nghymru, Iwerddon a'r Alban, cylwynedig i R. Geraint Gruffydd* (Cardiff) 122–42; 'Celtic religion', *The Oxford Classical dictionary*, 3rd ed., ed. Simon Hornblower and Antony Spawforth (Oxford) 1298–99; 'Narrative openers and progress markers in Irish', *A Celtic florilegium: studies in memory of Brendan O Hehir*, ed. Kathryn A. Klar, Eve E. Sweetser and Claire Thomas (Andover, MA) 104–20; 'A literary footnote: the Nun of Beare' *Festschrift for Professor D.S. Thomson, Scottish Gaelic Studies* 17, 205–12.

Pádraig Ó Macháin published *Riobard Bheldon: amhráin agus dánta* (Dublin).

Brian Ó Cuív, 'Irish language and literature 1845–1921', *A new history of Ireland, VI*, chap. 14,

385–304; 'Further comments on the Ó Gnímh family of Co. Antrim', *Scottish Gaelic studies* 17, 198–304.

Máirín Ní Dhonnchadha, ed. *Nua-léamha: gnéithe de chultúr, stair agus polaitíocht na hÉireann 1570–1900* (An Clóchomhar); review of Margaret MacCurtain and Mary O'Dowd, *Women in early modern Ireland* (Dublin 1991), *Éigse*; entries in *the Oxford companion to Irish literature*, ed. Robert Welch.

Thomas O'Loughlin, 'Seeking the medieval view of the Song of Songs', *Proceedings of the Irish Biblical Association* 18 (1995) 94–106; 'Biblical contradictions in the *Periphyseon* and the development of Eriugena's method', in G. van Riel, C. Steel. and J. McEvoy (eds) *Iohannes Scottus Eriugena: the Bible and hermeneutics* (Leuven) 103–25; ' "The gates of Hell": from metaphor to fact', *Milltown studies* 38, 98–114; 'The Latin sources of medieval Irish culture', in K. McCone and K. Simms (eds) *Progress in medieval Irish studies* (Maynooth) 91–105; 'Tyconius' use of the canonical Gospels', *Revue Benedictine* 106, 229–33.

Annual Report of the Governing Board of the School of Theoretical Physics for the year ending 31 December 1996 adopted at its meeting on 22 December 1997.

1 Staff, Scholars and Associates

SENIOR PROFESSORS: John T. Lewis (Director from 1 January 1975), Lochlainn S. O'Raifeartaigh

LIBRARIAN: Ann Goldsmith

SECRETARY: Margaret Matthews

EMERITUS PROFESSOR: James R. McConnell

SCHOLARS: N. Datta (India) to 31 January, 15 July - 30 November, C. Ford (England) to 30 April, D.J. O'Connor (Ireland), M. Rakowski (U.S.A.) to 30 June, I. Sachs (Switzerland), S. Vinnakota (India) from 23 September, C. Wiesendanger (Switzerland).

POSTDOCTORAL FELLOWS: M. Magro (France) from 25 June, A. Patrick (Russia) to 31 August, P. Upton (England) to 15 March.

GRADUATE STUDENTS: M. Davey (Ireland) to 30 September, K. Duffy (Ireland) from 16 September, M. Huggard (Ireland), B. McGurk (Ireland), R. Russell (Ireland), F. Toomey (Ireland), C. Walsh (Ireland), R. Whitley (Ireland) from 30 September to 11 October.

RESEARCH ASSOCIATES: Re-appointed to 31 December 1996:

DIAS: D. O'Mathúna

TCD: P.S. Florides, B.K.P. Scaife, D. Weaire

UCD: D.J. Judge, P. O'Donoghue, A. Ottewill, J.V. Pulé, W. Sullivan

ST. PATRICK'S COLLEGE MAYNOOTH: B. Dolan, D. Heffernan, F. Freire, C. Nash, A. O'Farrell, J.A. Slevin, D.H. Tchrakian

UCC: M. Vandyck

UCG: J. Burns, M.J. Conneely, M.P. Tuite, T.N. Sherry

DIT: T. Garavaglia, M. Golden, B. Goldsmith, P Houston, M.J. Tuite

DCU: M. Barman, E. Buffet, J. Burzlaff

LIMERICK UNIV.: R.H. Critchley, J. Kinsella, S. O'Brien

CARLOW RTC: D. O Sé

AT, & T: N. Duffield

BRIMS, BRISTOL: N. O'Connell

OPEN UNIVERSITY: A.I. Solomon

OXFORD UNIVERSITY: R.G. Flood

LAB. DE PROBABILITIES, FRANCE: P. McGill

METEOROLOGICAL SERVICE: P. Lynch

DEPT. OF FINANCE: A.J. Curran

SCHLUMBERGER CAMBRIDGE RESEARCH : B. Lenoach

INTERN. CENTRE FOR THEORETICAL PHYSICS, TRIESTE : J. Chela-Flores

UNAFFILIATED: G.M. O'Brien

VISITING SCIENTISTS: A.P. Balachandran (Syracuse) 23-29 May, J.G. Brankov (Sofia) 18 November - 13 December, J. Conlon (Michigan) 18-20 December, N. Datta (Marseille) 10-11 July, P. Dolan (Imperial College, London) 3-4 April, N. Duffield (AT, & T) 10-12 June, R. Ellis (Massachusetts) 8-15 April, M.E. Fisher (Maryland) 14-16 November, R. Flume (Bonn) 12 May - 7 June, C. Ford (Jena) 1-8 December, G.W. Ford (Ann Arbor) 3 June - 8 July, F. Freire (Heidelberg) 27 January - 4 February, A.J. Ganesh (BRIMS, Bristol) 6-10 February, K. Gawedzki (IHES, France) 3-6 February, C. Graham (Canada) 26 February - 30 April, 25 September - 23 December, J. Guven (Mexico) 1 September - 30 November, E. Ivashkevich (Dubna) 13-28 November, H. Joyce (Iceland) 19-21 December, M. Keane (CWI, Amsterdam) 2-5 November, R. Kenna (Liverpool) 25-27 March, M. Knecht (Orsay) 2-8 September, D. Litim (Imperial College, London) 25-31 January, D. MacKay (Cambridge) 25 March - 4 April, J. Madore (Orsay) 17-24 November, M. Magro (Lyon) 25 June - 31 December, J. Mairesse (BRIMS, Bristol) 6-11 February, K. Majewski (Munich) 8-15 March, T. Morris (Southampton) 27-30 October, A. Le Ny (Rennes) 6-13 April, N. O'Connell (BRIMS, Bristol) 6-11 February, 24 May - 3 June, 8-14 July, 3-9 October, 18-23 December, R.F. O'Connell (Louisiana) 10 June - 17 July, R. Olkiewicz (Imperial College, London) 24-28 July, J.M. Pawlowski (Jena) 1-4 July, E. Pechersky (Moscow)

4-13 October, 27 October - 17 November, B. Prabhakar (BRIMS, Bristol) 7-10 February, V.B. Priezzhev (Dubna) 2-30 September, V. Rubakov (Moscow) 15 October - 3 November, O. Schnetz (Erlangen) 7-31 October, W. Skrypnik (Kiev) 20 November - 18 December, A.I. Solomon (Open University) 13-17 May, D. Speiser (Basle) 30 April - 2 May, C. Stephens (UNAM, Mexico) 18-23 December, S. Tanimura (Tokyo) 4-6 September, E. Thomas (Groningen) 18-22 December, J. Wedagedera (Swansea) 3-5 April, H. Yoneyama (Japan) 25 July - 20 August, V. Zagrebnov (Marseille) 10-18 August.

2 General

A Long-Term Research Contract with the European Commission under its programme for research in information technology, ESPRIT, has provided financial support for six graduate students in the School.

3 Research and Study

3.1 Theoretical Particle Physics

Prof. O'Raifeartaigh's joint paper with Prof. McGlinn on the exhaustivity of canonical Wess-Zumino reductions was completed and sent for publication. A problem, left over from previous (1990-1995) work on Wess-Zumino-Toda reductions, was a discrepancy between the formulae for the central charge in two different gauges in the functional integral formulation. An investigation into this discrepancy, using the Fradkin-Vilenkin generalization of the BRST constraint-formalism, was begun in collaboration with Dr. Sreedhar. Work on the quantization of Wess-Zumino-Witten systems using functional integral methods, in collaboration with I. Sachs and C. Wiesendanger, was completed. This work was extended to obtain for the first time explicit expressions for the n-point functions in Wess-Zumino theory. Up to the present these functions have been known only implicitly as the solutions of the Knitchnik-Zamolodchikov (KZ) equations. The expressions obtained by us are quite complicated and an outstanding problem now is to check that the expressions do indeed satisfy the KZ equations. Work begun last year on the uniqueness of the Seiberg-Witten (SW) Ansatz, in collaboration with Prof. Flume and Drs. Magro, Sachs and Schnetz was completed. More recently the result was generalized to the case in which the SW super-multiplet interacts with matter. Both results have been sent for publication. The SW Ansatz has been checked at the one- and two-instanton levels by a number of groups using direct computations. Although the results of the computations agree with the SW result their theoretical justification is rather shaky. A program to place all instanton computations on a sounder basis was begun in collaboration with Drs. Sachs and Magro.

Prof. Chela-Flores conducted research in the interdisciplinary context of the chemical evolution and the origin of life.

Dr. Ford with Dr. Sachs studied electric magnetic duality. He worked with Dr. Wiesendanger on the renormalisation group.

Dr. Garavaglia completed theoretical work on the detection of the Higgs Boson. He continued a study of the relation between ordered Poisson brackets and Feynman systems. He also initiated a study of energy-time uncertainty relations for particle decay.

Dr. Magro worked on $N = 2$ supersymmetric Yang-Mills theory.

Dr. Nash studied quantum field theory including topology and statistical mechanics of models in low dimensions.

Dr. O'Connor worked primarily on the study of the field theoretic limit of lattice models obtaining exact solutions in a number of cases.

Dr. Sachs together with Prof. O'Raifeartaigh and Drs. Magro, Flume and Schnetz proved the uniqueness of the solution for the low-energy effective Lagrangian for $N = 2$ Yang-Mills theory proposed by N. Seiberg and E. Witten in 1994. In collaboration with Prof. O'Raifeartaigh and Drs. Lorio and Wiesendanger he established the necessary and sufficient conditions for scale-invariant Lagrangians to be at the same time conformally invariant. With Prof. O'Raifeartaigh and Dr. Wiesendanger he obtained an explicit path-integral solution of $SU(N)$ and $SL(N,R)$ WZW-models.

Prof. Tchrakian with Drs. Arthur and O'Brien completed the classical analysis of the

F^3-extended $SO(4)$ gauged Higgs model in 4-D. He gauged the non-relativistic Landau-Lifshitz model with $U(1)$. He performed SO(d) gauging of the d-dimensional $0(d+1)$ Skyrme/Sigma models. With Dr. Arthur he performed $SO(3)$ gauging of $O(4)$, usual Skyrme model in 3D and with Dr. Piette he performed $SO(2)$ gauging of $O(4)$ usual Skyrme model in 3D. With Drs. Young and Spruch he proved the existence of axially symmetric instantons in the 4p-dimension path Gen. Y.M. hierarchy. With Dr. Tinyakov he studied instantons and sphalerons in Skyrmed Weinberg-Selam model and in $SU(2)$ gauged Grassmannian model. He looked at the thermal transition rate in Skyrmed $O(3)$ sigma model with Drs. Müller-Kirsten and Zimmerschied and also the calculation of fluctuation determinants in $O(3)$ Skyrmed models.

Dr. Vinnakota worked on formulating the path integral quantization of the WZW — Liouville reduction, using the methods of Batalin, Fradkin and Vilkovisky for constrained systems, so as to address the problem of the conformal anomaly.

Dr. Wiesendanger worked on conformal field theory and on the renormalization group.

3.2 Applied Probability Theory

Professor Lewis continued his collaboration with Dr. Sullivan and Prof. Pfister. They completed work on a paper on the Asymptotic Equipartition Property. They collaborated with M. Davey and R. Russell on applying their results to the numerical simulation of stochastic process. They began work on an application of Large Deviation theory to Ergodic theory.

Work commenced on 1 January 1996 on the MEASURE project supported by a Long Term Research contract with the European Commission under its programme for research in information technology (ESPRIT). The organisations involved in the project are : DIAS-STP, Cambridge Laboratory and Telia Research (a wholly-owned subsidiary of Telia, the Swedish telecommunications company). The work involves applying Large Deviation theory to problems of resource allocation in broad-band networks and in computer operating systems. The theoretical work is the responsibility of the group in DIAS-STP under the leadership of Prof. Lewis. The novel aspect of the proposal is the method to be used for determining the rate-function of an arrivals process. The parametric modeling of the process is by-passed by use of direct estimation of the rate-function.

Six tasks were completed in 1996: the establishment of queue-server paradigms for ATM switches in the Cambridge Local Area Network and in the Telia Wide Area Network, the establishment of a queue-server paradigm for the Nemesis operating system, characterisation of demand in a public ATM network and the development of estimates of the rate-function for use in a local area network. The DIAS-STP group made major contributions in all of these tasks. An outcome of this work was the development of a near-optimal connection-acceptance-control algorithm. The intellectual property rights arising from this work have been protected by filing a patent application; they are owned in equal share by Cambridge University, DIAS and Telia.

Mr. Davey investigated the application of asymptotic equipartition property to the numerical simulation of arbitary stationary sources. He used techniques borrowed from Large Deviation theory and information theory.

Mr. Duffy investigated the transmission of information across loss nodes.

Ms. Huggard started work on the Nemesis operating system. She first developed a queue server paradigm with a view to applying large deviation ideas. In parallel with this work she studied large deviation theory and stochastic processes.

Mr. McGurk investigated the estimation of effective bandwidths using Measure ideas. He did some further simulation work, focussing on the Large Deviation properties of products of random $(max, +)$ matrices, and read complimentary material on the established statistical properties. He started some investigations of an application of the effective bandwidth estimation schemes to the problem of Call Acceptance Control in ATM networks. The algoritm being investigated was developed in collaboration with the Computer Laboratory in Cambridge. The design of a program, the Measure Toolkit, for carrying out experiments on the Measure estimators was agreed. With Mr. Russell and Telia Research Laboratory he conducted some experiments using the experimental ATM equipment. This work was to further investigate the queue-server paradigm for the Telia switch. He spent some time writing the prototype estimator module for the Measure

Toolkit, in collaboration with Horst Meyerdierks. He wrote simulation code for an improved version of the CAC algorithm, based on the Refined Effective Bandwidth estimator.

Mr. Russell worked mainly on applications of Large Deviation theory to queueing theory and the estimation of Large Deviation properties. He focussed on the sample path Large Deviations of random time-changes, investigating the lattice theory necessary to formulate the theory properly. He worked on implementing in C estimators based on the time-change formula and using simulations to study their statistics. He also developed software to analyse the statistical properties, in particular the Large Deviations behaviour of traces of network traffic.

Mr. Toomey worked on large deviations in stochastic discrete event systems.

Mr. Walsh with Dr. Duffield worked on the economies of scale in queueing networks.

3.3 Classical Statistical Mechanics

Dr. Buffet studied the statistical mechanics of random polymers. He also worked on mathematical finance.

3.4 Quantum Statistical Mechanics

Dr. Datta studied bulk and interfacial phase transitions in quantum lattice systems starting from classical lattice systems in $d \geq 2$ dimensions with a regular zero-temperature phase diagram, involving a finite number of periodic ground states. Subsequently she developed a perturbation technique to extend low-temperature analysis to lattice systems in which the quantum perturbation breaks the degeneracies of the classical ground states. She also analysed the thermodynamic properties of interfaces in the three dimensional Falicov-Kimball model.

3.5 Quantum Theory and Quantum Electronics

Prof. Scaife carried out research in the electrical and magnetic properties of material. He continued editing Volume IV of the Mathematical Papers of Sir William Rowan Hamilton.

Prof. Solomon studied the use of group theoretical methods applied to the analysis of quantum systems, including condensed fermion systems, and quantum optics, especially coherent and squeezed states of light. He also looked at the application of quantum groups to the analysis of deformed systems in physics, especially optics.

3.6 General Relativity and Gravitation

Dr. Dolan studied differential geometric techniques in quantum field theory, statistical mechanics and general relativity.

3.7 Applied Mathematics

Dr. Burzlaff continued his study of extended objects. He also investigated the nonlinear partial differential equations of Yang-Mills-Higgs theory and those of CP^n models.

Dr. Golden worked on linear viscoelastic boundary value problems where the boundary regions vary with time and on the thermodynamics of viscoelastic solids.

Dr. Lynch continued work on the development of a computer model for numerical weather prediction.

Dr. Vandyck continued his study of Lie and covariant differentiation of spinors. The role of conformal Killing vectors and conformal connections has been clarified. It is planned to use the resulting formalism in supermanifolds.

3.8 Pure Mathematics

Dr. Goldsmith investigated Abelian groups and modules with special reference to endomorphism rings and set-theoretic aspects.

Prof. O'Farrell worked on analytic capacities with Dr. Dowling. With Drs. Allen, Watson and Kabiko he worked on describing the closed subalgebras of the algebra of infinitely-differentiable functions on a smooth manifold. He also studied rational dynamics with Dr. List and he solved a problem about Sobolev space approximation raised by L.E. Fraenkel.

4 Research Reports

Research work during the year was written up in the first instance in research reports. Two lists of titles of these reports (preprints) were prepared and circulated to a mailing list of approximately 350 research institutes and university departments throughout the world. As

far as possible, copies of the preprints were sent out in response to requests. Many of the reports appeared later as publications. (See section 10.3).

DIAS-STP-96-

-1: R. FLUME: On the Baxterisation of Braid group representations of rational conformal field theories.
-2: A.E. PATRICK: The influence of boundary conditions on solid-on-solid models.
-3: J. BURZLAFF, & W.J. ZAKRZEWSKI: CP^2 soliton scattering : simulations and mathematical underpinning.
-4: M. RAKOWSKI, & S. SEN: Homology in Abelian lattice models.
-6: L. O'RAIFEARTAIGH, I. SACHS, & C. WIESENDANGER: Weyl-gauging and curved-space approach to scale and conformal invariance.
-8: A.E. PATRICK, & P.J. UPTON: Surface phase transitions in two dimensions: metastability and re-entrance.
-9: D. O'CONNOR, & C. NASH: Modular invariance, lattice field theories and finite size correlations.
-10: C. FORD, & C. WIESENDANGER: A multiscale subtraction scheme and partial renormalization group equations in the $O(N)$-symmetric ϕ^4-theory.
-11: L. O'RAIFEARTAIGH, I. SACHS, & C. WIESENDANGER: Weyl-gauging and conformal invariance.
-12: S. CROSBY, I. LESLIE, M. HUGGARD, J.T. LEWIS, B. MCGURK, & R. RUSSELL: Predicting bandwidth requirements of ATM and Ethernet traffic.
-13: L. O'RAIFEARTAIGH: Review of WZW-Toda reductions.
-14: J. CHELA-FLORES: A search for extraterrestrial eukaryotes: biological and planetary science aspects.
-15: C. WIESENDANGER: FSI in $\eta \to 3\pi$ and the quark mass ratio Q^2.
-16: C. WIESENDANGER: Instability of the vacuum in broken $O(N)$.
-17: T. GARAVAGLIA, & S.K. KAUFFMANN: Non-Grassman "Classicization"of Fermion dynamics.
-18: T.C. DORLAS, N. MACRIS, & J.V. PULÉ: The nature of the spectrum for a Landau Hamiltonian with Delta impurities.
-19: L. O'RAIFEARTAIGH: The evolution of the gauge principle.
-20: D. O'CONNOR: Casimir amplitudes in flat and curved spacetimes.
-21: R. FLUME, M. MAGRO, L. O'RAIFEARTAIGH, I SACHS, & O. SCHNETZ: Uniqueness of the Seiberg-Witten effective Lagrangian.
-22: R. FLUME, L. O'RAIFEARTAIGH, & I SACHS: Brief resume of Seiberg-Witten theory.
-23: E. BUFFET, & J.V. PULÉ: A model of continuous polymers with random charges.
-24: C. FORD, & C. WIESENDANGER: Multiscale renormalization.
-25: W.I. SKRYPNIK: Sine-Gordon transformations in nonequilibrium systems of Brownian particles with long-range interaction.
-26: L. O'RAIFEARTAIGH, I. SACHS, & C. WIESENDANGER: Absence of background charges in the $SU(2) - WZW$ model.
-27: C. FORD, & C. WIESENDANGER: The Higgs-Yukawa two-scale effective potential.
-28: D. O'CONNOR: Crossover in field theory.

5 Seminars, Review Lectures, Series, Courses

Seminar and review lectures, series, and courses, in specialised areas of physics and mathematics were given at DIAS-STP throughout the year, by members or visitors; as in previous years these were attended by members of staff and students from the universities and other third level and research institutes in the Dublin Area, and by members of the scientific schools of DIAS.

Seminars and lectures were given also under the auspices of the Dublin Particle Theory Group by the School's members and visitors.

5.1 Statutory Public Lecture

The statutory public lecture entitled *Fractal Image Coding* was delivered by Professor M. Keane (CWI Amsterdam) in Trinity College Dublin on 4 November.

5.2 Seminar and review lectures given at DIAS-STP

- Prof. J.G. Brankov (Bulgarian Academy of Science) *Configurational isomorphism of Abelian sandpiles, spanning trees and close-packed dimers on square lattices.*

- Dr. N. Datta *Phase transitions in the Falicov Kimball Model.*
- Dr. N.G. Duffield (AT, & T Research, N.J.) *A dynamical systems approach to tail exponents in polling models.*
- Prof. R. Ellis (Massachusetts) *Large deviation analysis of queueing systems.*
- Prof. M.E. Fisher (Maryland) *The statistical mechanics of ionic fluids : progress and challenges.*
- Prof. K. Gawedzki (IHES) *Universality or no universality in turbulent systems.*
- Dr. E.V. Ivashkevich (Dubna) *Symmetries and instantons in the stochastic Burgers equation.*
- Prof. M. Keane (CWI, Amsterdam) *The stochastic behaviour of continued fractions.*
- Dr. M. Knecht (Orsay) *The chiral structure of the QCD vacuum as seen from low-energy pi-pi scattering.*
- Prof. J. Madore (Orsay) *Fuzzy space-time and classical gravity.*
- Dr. D. MacKay (Cambridge) *Bayesian non-linear modelling and automatic relevance determination for neural networks*
- Mr. K. Majewski (Munich) *Large deviations of feedforward queueing networks.*
- Dr. N. O'Connell (BRIMS, Bristol) *Some large deviation results for sparse random graphs.*
- Dr. N. O'Connell (BRIMS, Bristol) *A large deviation principle for the order of a random permutation.*
- Dr. R. Olkiewicz (Imperial College , & Wroclaw) *Equilibrium states of Boson gases : an axiomatic approach.*
- Dr. J. Pawlowski (Jena) *Exact flow equations and the $U(1)$ problem.*
- Prof. E. Pechersky (Moscow) *The Ising model in image processing.*
- Prof. E. Pechersky (Moscow) *The large deviations of networks : an approach using the large deviation principle for input streams.*
- Prof. V.B. Priezzhev (JINR, Dubna) *Eulerian walks : recent work on a solvable model which displays self-organizing criticality.*
- Prof. W. Skripnik (Kiev) *Structure of correlation functions and thermodynamical limit in nonequilibrium systems of diffusing particles and oscillators.*
- Dr. O. Schnetz (Erlangen) *Natural renormalization.*
- Dr. Tanimura (Tokyo) *Quantization of homogeneous spaces.*
- Dr. P.J. Upton (Bristol) *Theory of wetting : exact results in 2-dimensions.*
- Prof. T.T. West (TCD) *Ergodic theory and the uniform distribution.*
- Dr. H. Yoneyama (Japan) *CP^{N-1} model with topological term and fixed point action on a lattice.*
- Prof. V.A. Zagrebnov (Marseille) *Hamiltonians for singular perturbations.*

5.3 Seminars given by the Dublin Particle Theory Group in DIAS and elsewhere in Ireland

- Dr. J. Burzlaff (DCU) *CP^2 soliton scattering.*
- B. Dolan (Maynooth) *Symplectic structures and Ashtekar variables.*
- C. Ford (Jena) *Instantons on the four-torus.*
- Dr. F. Freire (Heidelberg) *The strong 3D infrared running of the gauge coupling.*
- Prof. K. Gawedzki (IHES) *The WZW functional integral at genus one and the Bethe Ansatz.*
- Dr. J. Guven (UNAM, Mexico) *Edge constraints on the geometry of relativistic extended objects.*
- Mr. D. Litim (Imperial College, London) *An exact renormalisation group at work : the superconducting phase transition.*
- Dr. M. Magro *$N = 2WZW$ and Toda models.*
- Dr. T. Morris (Southampton) *Derivative expansion of the renormalisation group.*
- Dr. A. Ottewill (UCD) *Gravitational radiation from cosmic strings.*
- Prof. V.A. Rubakov (INR, Moscow) *Baby universes, quantum coherence and energy conservation.*
- Dr. I. Sachs *Non-perturbative running coupling and duality in supersymmetric QCD.*

- Dr. I. Sachs *Is the Seiberg-Witten effective action unique?*
- Dr. S. Vinnakota *The Batalin-Fradkin-Vilkovisky formalism for constrained systems.*

5.4 Lecture Courses and Seminars given in Ireland by members of DIAS-STP

- Prof. J.T. Lewis *Probability Theory* (Maths 412, TCD)
- Prof. L. O'Raifeartaigh *Gauge Theory and Particle Physics* (M.Sc Course, DIAS)
- Mr. R. Russell *From Boltzmann to gzip, from Cramer to Nemesis* (D.U.M.S., TCD)
- Mr. R. Russell and Mr. F. Toomey *Statistical Mechanics* (Maths 433, TCD)
- Dr. I. Sachs *Weyl-gauging and conformal invariance* (TCD)
- Dr. C. Wiesendanger *A multi-scale subtraction scheme and partial RGE in the $O(N)$-symmetric μ^4-theory*

5.5 Seminars, Lectures and Courses given abroad

- Prof. J.T. Lewis *An application of statistical mechanics to information theory* (Paris) *Equipartition measures and reconstruction sequences* (Haifa) *From physics to quantum probability and back* (Vienna) *A fresh look at the asymptotic equipartition property* (Bristol) *An introduction to Large Deviation theory for teletraffic engineers* (Lausanne) *Mathematical research at DIAS* (Billund) *A near-optimal call acceptance control algorithm based on online estimation of entropy* (Budapest)
- Prof. L. O'Raifeartaigh *Weyl gauging and conformal invariance* (Calcutta; Japan) *WZW-Toda reductions* (Calcutta) *Seiberg-Witten theory* (Calcutta; Seoul, Korea; Goslar; Tbilisi, Georgia; Bonn; Wuppertal; Koln) *The dawning of gauge theory* (Bombay) *Review of Seiberg-Witten theory* (Japan) *Origins of gauge theory* (Japan; Bonn; Wuppertal; Koln) *Laudatio for the Award of the 1994 and 1996 Wigner medals to V. Kac and R. Moody* (Goslar)
- Dr. N. Datta *Quantum perturbations of classical lattice systems* (Rutgers, NJ) *Ground state selection* (Univ. California, Davis) *Convergent perturbation expansions for quantum lattice systems* (Univ. Arizona, Tucson) *Quantum Pirogov Sinai theory* (Prague) *Stability of classical lattice systems under quantum perturbations* (Imperial College)
- Ms. M. Huggard *Predicting bandwidth requirements of ATM and ethernet traffic* (Glasgow) *A queue server paradigm for the Nemesis operating system* (Bristol)
- Mr. R. Russell *The Large Deviations of random time-changes* (BRIMS, Bristol) *An introduction to Large Deviations for teletraffic engineers* (Lausanne)
- Dr. I. Sachs *Non-perturbative running coupling and duality in supersymmetric QCD* (Glasgow; Rochester; London, Ontario) *Uniqueness of the Seiberg-Witten effective action* (Cambridge; London) *Ongoing work in supersymmetric QCD* (ENS,Paris) *Subtle properties in 2-dimensional QFT* (Rochester)
- Mr. F. Toomey *Large deviations of products of random max-plus matrices* (Edinburgh; Bristol) *Exploring the queueing behaviour of ATM switches* (Lausanne) *Resource allocation in multi-media operating systems* (Cambridge)
- Dr. C. Wiesendanger *No background charges on $SU(2)-WZW$ model on the sphere* (Jena) *Invariant correlations of WZW-models: $SL(3,R)$ and $SU(3)$ as simple examples* (Moscow) *Final state interactions in $\eta \to 3\pi$* (Trento) *Resummation of large logs in the $O(N)$-symmetric μ^4-theory* (Dubna)

6 Activities of Members of DIAS-STP

6.1 Activities within Ireland

PROF. L. O'RAIFEARTAIGH: Third annual meeting of Irish Theoretical Particle Physics Group, TCD, May.

DR. D. O'CONNOR: Irish Quantum Field Theory Meeting, 24-25 May.

DR. I. SACHS: Irish Quantum Field Theory Meeting, 24-25 May.

DR. C. WIESENDANGER: Irish Quantum Field Theory Meeting, 24-25 May.

6.2 Activities outside Ireland

PROF. J.T. LEWIS: ESPRIT Measure Project, Telia Research, Sweden 10-13 January; Rencontre de Physique Statistique, École Polytechnique, Paris 24-28 January; Mark Kac Seminar, Amsterdam 1-3 March; UKTS, Strathclyde 18-20 March; Measure Meeting, Cambridge 15-16 April; IEEE/ITW96 Haifa 8-14 June; BRIMS Workshop, Bristol 17-19 June; Cambridge 26-27 June; Summer Institute, CNRS, Marseille 29 June - 7 July; 4th World Congress Bernoulli Society, Vienna 25 August - 9 September; Rennes, France 22-25 September; Lausanne - Performance 96 7-9 October; Statistical Mechanics of Large Networks, INRIA, Paris 20-23 October; Hewlett-Packard Laboratories, Bristol 31 October - 2 November; Meeting of Directors of European Mathematical Research Centres, Billund, Denmark 7-9 November; RITE Project, Cambridge 14-15 November; Ericsson/TUB Meeting, Budapest 27-29 November; Stochastic Networks Workshop, Cambridge 13-14 December.

PROF. L. O'RAIFEARTAIGH: 75 Years of Quantum Mechanics and Recent Trends in Theoretical Physics, Indian Statistical Institute 26 January - 8 February; Ecole Normale Superieure de Lyon, France 8-14 February; Institute for Nuclear Research, Tokyo 1-30 April; Meeting on Restructuring of Ukrainian Science, Kiev 10-14 May; Conference of Asian Pacific Centre for Theoretical Physics 5-10 June; XXI International Colloquium on Group Theoretical Methods in Physics, Goslar, Germany 15-20 July; Workshop on Selected Topics in Modern Mathematical Physics, SIMI, Tbilisi, Georgia 22-28 September; 60th Birthday celebration for Prof. N. Straumann, Zurich, October; Universities of Bonn, Köln and Wuppertal 25-30 November.

DR. N. DATTA: Universities of Rutgers, California at Davis, Arizona 25 September - 11 October; Autumn School on The Mathematics of Phase Transitions, Prague 20-31 October; Imperial College, London 21-22 November.

MR. M. DAVEY: Stochastic Networks Workshop, Cambridge 13-14 December.

MR. K. DUFFY: RITE Project, Cambridge 12-14 December.

MS. M. HUGGARD: Esprit Project, Telia Research Institute, Stockholm 10-14 January; U.K. Teletraffic Symposium, Glasgow 18-20 March; Esprit Project, Computer Laboratory, Cambridge 14-16 April; Pegasus II Workshop, Glasgow 2-4 October; RITE Project, Cambridge 14-15 November; Esprit Project, BRIMS, Bristol, & Cambridge 7-14 December.

MR. B. MCGURK: Telia Research Institute, Stockholm 5-11 August.

DR. D. O'CONNOR: JINR, Dubna 25 March - 20 May : 16 August - 6 September.

DR. M. RAKOWSKI: Visiting Universities in USA 21 April - 12 May.

MR. R. RUSSELL: Esprit Project, Telia Research Institute, Stockholm 10-14 January; North British Probability Seminar, Edinburgh 18-20 January; Esprit Project, Computer Laboratory, Cambridge 14-16 April; Methods for the Performance Evaluation and Design of Broadband Multiservice Networks, Paris 1-6 June; BRIMS Workshop, Bristol 17-19 June; Cambridge 25-28 June; Measure Project, Stockholm 5-11 August; Lausanne - Performance 96 5-12 October; RITE Project, Cambridge 14-15 November; Stochastic Networks Workshop, Cambridge 13-14 December.

DR. I. SACHS: University of Tours and Ecole Normal Superieure, Paris 20-25 February; Glasgow 10-13 March; Workshop on Continuous Advances in *QCD*, University of Minnesota 27 March - 1 April; Western Ontario 2-18 April; Geometry and Quantum Field Theory Workshop, Isaac Newton Institute, Cambridge 18 November - 1 December.

MR. F. TOOMEY: Esprit Project, Telia Research Institute, Stockholm 10-14 January; North British Probability Seminar, Edinburgh 18-20 January; UK Teletraffic symposium, Glasgow, March; Esprit Project, Computer Laboratory, Cam-

bridge 14-16 April; Methods for the Performance Evaluation and Design of Broadband Multiservice Networks, Paris 3-6 June; Trends in Communications, BRIMS, Bristol June; Esprit project, Glasgow 2-4 October; Lausanne - Performance 96 6-13 October; RITE Project, Cambridge 14-15 November; Glasgow 20-21 November, Esprit Project, BRIMS, Bristol, 7-14 December; Stochastic Networks Workshop, Cambridge December.

MR. C. WALSH: Stochastics Networks Workshop, Cambridge December.

DR. C. WIESENDANGER: Workshop on The Standard Model at Low Energies, Trento, Italy 25 April - 15 May; 28th International Conference on High Energy Physics, Warsaw and Visit to Jena 11 July - 1 August; ITEP Moscow 21-24 August; RG '96, Dubna 25-31 August; Zurich 18 September - 2 October.

7 Symposia

Two Mathematical Symposia were held during the year, 3-4 April and 19-20 December. The attendance (36 in April, 42 in December) included professors, lecturers, and graduate students from the Irish universities and other third-level and research institutes, and from institutes abroad, and members of the scientific schools of DIAS.

Lectures were given as follows:

April

Review Lectures:

- Dr. D. McKay (Cambridge) *Good error-correcting codes based on very sparse matrices.*
- Dr. S. Buckley (Maynooth) *The Sobolev imbedding theorem on general domains.*

Lectures:

- Dr. D. Heffernan (Maynooth) *Quantum chaos.*
- Dr. B. Dolan (Maynooth) *A geometric approach to the renormalisation group.*
- Dr. J. Sexton (TCD) *Glueball decays by computer.*
- Mr. F. Toomey (DIAS) *Discrete event dynamical systems : mathematical models for computing and communications.*

Short Talks:

- Prof. A. O'Farrell (Maynooth) *An example on Sobolev space approximation.*
- Mr. C. Watt (TCD) *Finsler metrics and complex curves.*
- Dr. P. Dolan (Imperial College) *A fresh look at the Goldberg-Sacks theorem.*
- Dr. A. Patrick (DIAS) *The puzzle of the Hysteresis loop.*
- Mr. J. Wedagedera (Swansea) *The van Hemmen model of a spin-glass.*

December

Review Lectures:

- Prof. E.G.F. Thomas (Groningen) *The discrete path integral.*
- Prof. J. Conlon (Ann Arbor , & Oxford) *Problems in stochastic partial differential equations.*

Lectures:

- Prof. C. Stephens (UNAM, Mexico) *Genetic algorithms : from statistical mechanics to evolution.*
- Dr. H. Joyce (Jyvaskyla Univ., Finland) *Rectifiability, curvature and singular integrals.*
- Dr. I. Sachs (DIAS) *The Seiberg-Witten theory.*
- Prof. J.N. Flavin (U.C.G.) *Some properties of nonlinear diffusion equations.*

Short Talks:

- Dr. B. Goldsmith (D.I.T.) *Quasi-minimal Abelian groups.*
- Prof. A. Wood (D.C.U.) *Stokes' method for convergent series.*
- Prof. J.T. Lewis (DIAS) *Large deviation theory : the bare essentials.*
- Dr. N. O'Connell (BRIMS, Bristol) *Why exponential tilting?*
- Dr. T. Murphy (T.C.D.) *Particles in JAVA.*

8 Workshop

A working seminar organised by the Dublin Applied Probability Group in connection with the *Esprit Project* was held 7 - 9 February.

Lectures were given as follows :

- Dr. J. Mairesse (BRIMS, Bristol) *Stochastic linear systems in the (max, +) algebra.*
- Dr. A.J. Ganesh (BRIMS, Bristol) *Estimating effective bandwidths for AR and Markov sources.*
- Prof. J.T. Lewis *Coding and simulation : an examination of the asymptotic equipartition property.*
- Dr. A.J. Ganesh (BRIMS, Bristol) *On the sample path of departures from a shared buffer.*
- Dr. N. O'Connell (BRIMS, Bristol) *Large deviations for sample paths indexed by the half-line.*
- Mr. R. Russell *Estimating effective bandwidths of network traffic.*
- Dr. B. Prabhakar (BRIMS, Bristol) *Entropy methods in communications networks.*
- Mr. F. Toomey *Large deviations of some (max, +) recursions.*

A presentation outlining current research by Members of the School was made to the Board of the School on 11 July.

- Dr. D. O'Connor *Universality in phase transitions.*
- Dr. I. Sachs *Latest attractions in strong interactions.*
- Dr. N. Datta *Competition between quantum and thermal fluctuations in strongly correlated electron systems.*
- Mr. R. Russell *Measuring the entropy of a traffic stream.*
- Ms. M. Huggard *A queue-server paradigm for the Nemesis operating system.*
- Mr. F. Toomey *Discrete event dynamical systems.*

9 Visitors

As in previous years, visitors from abroad came to the School for short or long periods, for discussions with School's members, to give seminars, and to avail of the School's library resources for their research work. For lectures given by visitors, see section 5.2

Short visits (up to one week):

A.P. Balachandran (Syracuse) 23-29 May
J. Conlon (Michigan) 18-20 December
N. Datta (Marseille) 10-11 July
P. Dolan (Imperial College, London) 3-4 April
N. Duffield (AT , & T) 10-12 June
R. Ellis (Massachusetts) 8-15 April
M.E. Fisher (Maryland) 14-16 November
C. Ford (Jena) 1-8 December
A.J. Ganesh (BRIMS, Bristol) 6-10 February
K. Gawedzki (IHES, France) 3-6 February
H. Joyce (Iceland) 19-21 December
M. Keane (CWI, Amsterdam) 2-5 November
R. Kenna (Liverpool) 25-27 March
M. Knecht (Orsay) 2-8 September
D. Litim (Imperial College, London) 25-31 January
J. Madore (Orsay) 17-24 November
J. Mairesse (BRIMS, Bristol) 6-11 February
K. Majewski (Munich) 8-15 March
T. Morris (Southampton) 27-30 October
A. Le Ny (Rennes) 6-13 April
N. O'Connell (BRIMS, Bristol) 6-11 February, 24 May - 3 June, 8-14 July, 3-9 October, 18-23 December
R. Olkiewicz (Imperial College, London) 24-28 July
J.M. Pawlowski (Jena) 1-4 July
B. Prabhakar (BRIMS, Bristol) 7-10 February
A.I. Solomon (Open University) 13-17 May
D. Speiser (Basle) 30 April - 2 May
C. Stephens (UNAM, Mexico) 18-23 December
S. Tanimura (Tokyo) 4-6 September
E. Thomas (Groningen) 18-22 December
J. Wedagedera (Swansea) 3-5 April
V. Zagrebnov (Marseille) 10-18 August

Longer visits:

J.G. Brankov (Sofia) 18 November - 13 December
R. Flume (Bonn) 12 May - 7 June
G.W. Ford (Ann Arbor) 3 June - 8 July
F. Freire (Heidelberg) 27 January -

4 February
C. Graham (Canada) 26 February - 30 April, 25 September - 23 December
J. Guven (Mexico) 1 September - 30 November
E. Ivashkevich (Dubna) 13-28 November
D. MacKay (Cambridge) 25 March - 4 April
M. Magro (Lyon) 25 June - 31 December
R.F. O'Connell (Louisiana) 10 June - 17 July
E. Pechersky (Moscow) 4-13 October, 27 October - 17 November
V.B. Priezzhev (Dubna) 2-30 September
V. Rubakov (Moscow) 15 October - 3 November
O. Schnetz (Erlangen) 7-31 October
W. Skripnik (Kiev) 20 November - 18 December
H. Yoneyama (Japan) 25 July - 20 August

10 Publications

10.1 Books

10.2 Communications of the Dublin Institute for Advanced Studies, Series A (Theoretical Physics)

None published.

10.3 Contributions to periodical and other publications

L. O'Raifeartaigh: The evolution of the gauge-principle. *Bull. Assoc. Asia Pacific Phys. Soc.* **6**(1996)2.

C. Ford, & L. O'Raifeartaigh: Canonical quantization of interacting WZW theories. *Nucl. Phys. B* **460**(1996)203.

R. Flume, L. O'Raifeartaigh, & I Sachs: Brief resume of Seiberg-Witten theory. *Proc. Inaugural Conference, Asian Pacific Center for Theoretical Physics, Seoul, 1996.*

F. Toomey: Bursty traffic and finite capacity queues. *Annals of Operations Research, Special Issue on Queueing Networks with Finite Capacity.*

N.G. Duffield, J.T. Lewis, N. O'Connell, R. Russell, & F. Toomey: Predicting quality of service for traffic with long range fluctuations. *IEEE ICC '95 Proceedings 1995.*

G.W. Ford, J.T. Lewis, & R.F. O'Connell: Master equation for an oscillator coupled to the electromagnetic field. *Annals of Physics* **252**(1996)362-385.

S. Crosby, I. Leslie, M. Huggard, J.T. Lewis, B. McGurk, & R. Russell: Predicting bandwidth requirements of ATM and Ethernet traffic. *Proc. 13th U.K. Teletraffic symposium, Glasgow, 1996.*

M.A. van Eijck, D. O'Connor, & C.R. Stephens: Heating field theory the "environmentally friendly" way! *Proceedings of the 3rd. Workshop on Thermal Field Theories and their Applications, Banff, Canada 1993 edited by F.C. Khanna et al., World Scientific 1994, pp63-71.*

C. Nash, & D. O'Connor: Modular invariance of finite size corrections and a vortex critical phase. *Phys. Rev. Lett.* **76**(1996)1196-1199.

J. Gaite, & D. O'Connor: Field theory entropy and the renormalisation group. *Phys. Rev. D* **54**(1996)5163-5173.

F. Freire, D. O'Connor, C.R. Stephens, & M.A. van Eijck: Finite temperature renormalization group predictions : the critical temperature exponents and amplitude ratios. *Thermal Field Theories and Their Applications edited by Y.X. Gui et al., World Scientific 1996, pp383-389.*

J.-G. Zhou, J.-Q. Liang, J. Burzlaff, & H.J.W. Müller-Kirsten: Instanton induced tunneling amplitude at excited states with the LSZ method. *Phys. Lett. A* **224**(1996)142-146.

J. Burzlaff, & W.J. Zakrzewski: CP^2 soliton scattering : simulations and mathematical underpinning. *Nonlinearity* **9**(1996)1317-1324.

J. Burzlaff, & D.H. Tchrakian: Zero modes of rotationally symmetric generalized vortices and vortex scattering. *J. Math. Phys* **37**(1996)650-657.

D.H. Tchrakian: Skyrme-like models in gauge theory. *Constraint theory and quantisation methods edited by F. Colomo, L. Lusanne and G. Marmo, World Scientific, 1994.*

K. Arthur, & J. Burzlaff: Existence theorems for π/n vortex scattering. *J. Math. Phys.* **36**(1996)311-318.

J. Chela-Flores: Preservation of relics from the RNA world through natural selection, symbiosis and horizontal gene transfer. *Acta Biotheoretica* **44**(1996)169-177.

B. Dolan: Chaotic behaviour of renormalisation flow in a complex magnetic field. *Phys. Rev. E* **52**(1995)4512-4515.

M.A. Vandyck: On the damped harmonic oscillator in the de Broglie-Bohm "Hidden-Variable" theory. *J. Phys.A* **27**(1994)1743.

11 Library

Three hundred new titles were added to the library stock during the year; one hundred and thirty current periodicals were taken, of which approximately fifty were received by gift or under exchange arrangements. As in previous years, offprints and preprints were received from many scientific institutes and university departments at home and abroad, either directly or in response to requests. Computerisation of the main author catalogue continued.

Annual Report of the Governing Board of the School of Cosmic Physics for the year ending 31 December 1996 adopted at its meeting on 20 March 1997.

1 Staff, Scholars and Associates

SENIOR PROFESSORS: L.O'C. Drury, A.W.B. Jacob (Director, to 31 October), E.J.A. Meurs (Director, from 01 November).

PROFESSORS: A. Thompson, (two vacancies).

ASSISTANT PROFESSORS: D. O'Sullivan, T.P. Ray, P.W. Readman.

RESEARCH ASSISTANTS: I. Elliott, (two vacancies).

EXPERIMENTAL OFFICERS: T.A. Blake, B.D. Jordan, W.-M. Tai.

VISITING SCIENTISTS: P. Beck (Austrian Research Centre, Seibersdorf, Austria), C. Birt (University of Leicester), K. Bonjer (University of Karlsruhe), C. W. A. Browitt (BGS, Edinburgh), F. Carrilho (Met. Institute, Lisbon), E. Criley (US Geological Survey, Menlo Park), R. Dendy (Culham, England), D. C. Ellison (North Carolina, USA), B. Feignier (EMSC, Paris), S. Gregersen (KMS, Copenhagen), V. Haak (GFZ, Potsdam), K. Hinzen (University of Cologne), V. Icke (Leiden Observatory), R. Keller (University of Texas, El Paso), M.A. Khan (University of Leicester), P . Kiraly (KFKI, Budapest), T. Lago (University of Porto, Portugal), D. Lemke (MPIA, Heidelberg, Germany), P. Maguire (University of Leicester), J. Mechie (GFZ, Potsdam), J. Mezcua (IGN, Madrid), A. Nyblade (Pennsylvania State University), H.-T. Pho (IPG, Strasbourg), O. Pols (IoA, Cambridge), C. Prodehl (Univesity of Karlsruhe), I. L. Rasmussen (Copenhagen, Denmark), C. Rola (IoA, Cambridge), Ch. Saentz (INTA, Madrid, one month, July-August), V. Sakkas (University of Leicester), F. Simpson (GFZ, Potsdam), R. Sleeman (KMNI De Bilt, Netherlands), H. Thybo (University of Copenhagen), M. Tsiganis (University of Thessaloniki, Greece, February-June), R. Verbeiren (Royal Observatory, Brussels), A. Walker (BGS, Edinburgh), J. Webb (Univesity of New South Wales), A. Westphal (Berkeley, USA), R. White (Fulbright Professor, from September).

TECHNICAL AND CLERICAL STAFF: G. Broderick, A. Byrne, A.M. Callanan, E. Clifton, P. Daly (part-time, from 07 May), W. Dumpleton, E. Flood, A. Grace-Casey, C.M. Horan, S. Ledwidge, D. Meghen, M. Smyth, H. Sullivan, G. Wallace, V. Ward (from 05 April to 30 June), (three vacancies).

SCHOLARS: G.F. Byrne, J. Donnelly (from 01 January), T. Downes, K. Farrell, A.J. Keane, R. Keegan (from 22 July), M. Landes (from 01 April), K. McGrane (from 01 August), F.E. Murphy, L. Nazarova (to 22 March), L. Norci (to 15 January), O. Novak, A. O'Brien (from 01 November), B.M. O'Reilly, S. O'Sullivan, A. Scally (from 01 October), M.I. Wilkinson (to 30 September), Z. Zang, D. Zhou (from 01 August).

PROJECT SUPPORTED POSITIONS: C.J. Davis (Jets from Young Stars, from 01 January), F. Hauser (COMBONET), L. Norci (High Energy Studies of Star Formation, from 15 January), S.C. Russell (ISOPHOT, to 30 June), J. Vermeulen (GLORIA, to 31 March).

PROFESSORS EMERITI: H.A. Bruck, T. Murphy, C. O Ceallaigh (to 10 October)*, P.A. Wayman.

RESEARCH ASSOCIATES: C.J. Bean (UCD), P.B. Byrne (Armagh), M. Cawley (SPCM), D. Corcoran (UL), P. Duffy (UCD, from 01 June), R. Keary (GSI), A. Lawrence (Edinburgh, from 01 November), B. McBreen (UCD, from 01 November), J. Makris (Hamburg), P. Morris (British Antarctic Survey), N.P. Murphy (BP), F. Murtagh (NUU, from 01 December), W.E.A. Phillips (TCD), V.F. Polcaro (IAS, Frascati, from 01 November), C. Prodehl (Karlsruhe), S.C. Russell (UCD, from 01 July), P.M. Shannon (UCD).

PROJECT STUDENTS: A. Hevey (TCD, 01 October to 31 December), A. Kelly (TCD, 0l October to 31 December), D. Mahon (TCD, 01 October to 31 December).

VACATION STUDENTS: J. Cuniffe (TCD, 26 June to 12 July), A. Hevey (TCD, 01 July to 16 August), S. Jacob (TCD, 01-21 November), D. O'Connell (Terenure College, 01 July-27 September), C. Power (TCD, 01-12 July), L. Sweetman (TCD, 03 July-31 August).

*C. O Ceallaigh died on 10 October 1996.

2. Research Activities in the Geophysics Section

2.01 KRISP (Seismic Programme in Kenya)

G.F. Byrne, O. Novak, A.W.B. Jacob and staff of European, United States and Kenyan Institutions

Progress was made in interpreting the crustal structures on the eastern flank of the Rift, the Chyulu Hills volcanic field and the underlying lower lithospheric structures along the whole profile from the Indian Ocean to Lake Victoria.

The Chyulu Hills is one of the few locations where detailed geochemical, thermobarometric, seismological and gravity data are available. The crust is about 44 km thick with a thick zone of low velocity and high Poisson's ratio in the lower crust. The seismic data can be explained by either an anorthositic body directly above the Moho or by the presence of partial melt. Mantle xenoliths suggest an apparent lithospheric thickness of about 105 km and there is evidence that lower lithospheric heating was caused by stagnating magma, with the effects at greater depths offset to the east.

In the lower lithospheric study of the whole KRISP profile, the mantle reflectors could represent upper mantle shear zones (as postulated for the western European lithosphere in previous work by the Section), plume head induced shearing flow in the region of the rift, compositional heterogeniety, flow induced anisotropy, regions of melt within the upper mantle (especially under the Chyulu Hills, see above) or a complicated mixture of mechanisms. Two reflectors have been found at about 51 and 63 km beneath the rift and the western flank. The more continuous one at 51 km shallows to about 43 km underneath the rift, indicating that structures at that depth are deflected but not destroyed by the rift processes. This probably is a pre-rift feature and provides some control over the depths to which large quantities of asthenospheric material have penetrated. Beneath the southeastern flank the structure is more variable. The Quaternary volcanism of the Chyulu Hills may have disrupted pre-existing structures.

2.02 RAPIDS - Seismic Profiles in the Northeastern Atlantic

F. Hauser, B.M. O'Reilly, P.W. Readman and A.W.B. Jacob with P.M. Shannon (UCD) and the University of Hamburg

Modelling of the wide-angle seismic and satellite gravity between the Rockall Bank and the Iceland Basin in the North Atlantic was completed. Crustal and sedimentary structure have been resolved in the Hatton Basin and across the Hatton Continental Margin (HCM) east of magnetic Anomaly 24. The structure of the oceanic crust west of the anomaly was also determined. In the RAPIDS experiment, ocean bottom seismometers deployed at 1.0 km intervals and the dominant frequency (6 Hz) of the seismic source used, define the resolution limit of the seismic data. This lies near the resolution capability of satellite gravity to define structure at shorter spatial wavelengths (i.e. less than 20 km). The gravity data support the seismic model in areas of good seismic coverage and has been used to control the model where the wide-angle seismic coverage is weak. A two-layer sedimentary sequence is present in both the Hatton Basin and across the continental margin. The lower layer, with a P-wave velocity of about 4 km/s, is interpreted as pre-Eocene synrift sediments and is up to 3.5 km thick. A younger and thinner (1.0 to 2.5 km) post-rift sequence, with a velocity of about 2 km/s, defines a strong velocity contrast which suggests an erosional unconformity surface.

The sedimentary structure is distinctly different to that in the Rockall Trough, where a third intermediate layer (Vp ≈ 3 km/s) occurs. The three-layer crust, characterised by two intracrustal reflections PiP1 and PiP2, varies from 30 km thick under the Rockall Bank to about 15 km below the Hatton Basin, where it is stretched by a factor of two relative to onshore Ireland. The crust is thinnest below the Hatton Bank, where the presence of a single intracrustal reflection indicates that the lower crustal layer thins to below the seismic resolution limit. Below the HCM a region of thick lower crust with anomalously high velocity (Vp ≈ 7.2 km/s) is resolved by the seismic and gravity data. It is connected (west of Anomaly 24) to a region of oceanic crust which is thicker than in the Iceland Basin. These relationships between the thick lower crust below the HCM and the oceanic crust in the Iceland Basin are interpreted as evidence for magmatic underplating, consistent with previous models for the HCM. The inferred unconformity surface between the syn-rift and post-rift layers may be due to regional uplift driven by upwelling of hot asthenosphere before Anomaly 24 (Early Eocene) time.

2.03 COMBO (the Core-Mantle Boundary Project)

A.W.B. Jacob, F. Hauser, F.E. Murphy and G. Wallace with J. Neuberg and A. O'Mongain (Leeds), C. Prodehl (Karlsruhe), R. Kind (Potsdam), L.A. Mendes-Victor and N. Dias (Lisbon)

COMBO was given permission to go ahead in the early summer and shot windows were planned for late July. Because of the previous delay there were to be fewer special deployments and the coordinator, A.W.B. Jacob, purposely did not encourage special deployments on a large scale. The main aim of the project was to produce signals visible on the world seismic network, though special deployments would have been a bonus. It was fortunate that this was the policy because the licences were suddenly suspended, though not cancelled, a few days before the deployment after a sensationalized and inaccurate newspaper article was published. The subject then became a political and media event, with almost no connection to reality, and the experimental work has been suspended indefinitely. Because of the earlier delay, and because the group sensibly calculated that there was a chance that the shots might not be fired, work was already in progress in Dublin, Leeds, Lisbon and Potsdam to minimize the effect and to carry out studies of the core-mantle boundary region by other means.

In Dublin, F. Murphy used the signals from nuclear tests in the Pacific which were recorded in the western United States, and a fortuitous recording of a Chinese nuclear test on the VARNET profile A, to study the core-mantle boundary with PcP phases using relatively simple sources. This has worked well with a good model of a zone in the eastern Pacific whose characteristics indicate significant variations in velocity for the D" zone (-0.5 to +1.5 per cent) around the standard earth model. The topographical variations required to explain the observed P-PcP differential times would be too extreme and would produce extreme amplitude variations, which are not observed. This is an important conclusion.

A. O'Mongain, in Leeds, has used a different approach. She has taken recordings of PdP phases from earthquakes at greater range to study the D" zone. This has also produced unexpected results which, too, throw doubt on accepted models for the D" zone. In the light of these developments, N. Dias has moved from Lisbon to Potsdam and is conducting a study using the broad band network in central Europe. This enables him to use S waves as well, a source of important extra information.

In other work being carried out in Dublin, F. Hauser worked with teleseismic events, including the Chinese nuclear test, recorded on the VARNET array. These teleseismic events, together with the refraction data, had to be converted into Seismic Handler format. Several conversion programs had to be written to take into account the different formats of the instruments (REFTEK-SEGY, PASSCAL-SEGY, EDL-format). Working with the actual data therefore started only later in the year. Because of the close station spacing (about 1.0 km) this data set is unique. Teleseismic recordings of this density have not previously been obtained. Several different research topics are possible. One is using these events to look at the crustal and upper mantle structure under Ireland using both seismic receiver functions and tomography. This work is being carried out by F. Hauser with F. Masson of the University of Karlsruhe.

2.04 VARNET

A.W.B. Jacob, M. Landes and the entire staff of the Section at various times, with staff of UCD, UCG, Geological Survey of Ireland, Universities of Karlsruhe, Berlin, and Copenhagen and GFZ Potsdam

This was a major commitment for the Section. Final detailed planning, permissioning, and other preparations started at the beginning of the year. The R.V. LOUGH BELTRA was made available by the Department of the Marine and details of the seismic shooting at sea were set up with Irish Offshore Diving Ltd of Cork, who also assisted with the land-locked shots. This was the biggest wide-angle seismic project ever carried out in Ireland or Britain. Including the old analogue stations (low dynamic range, short recording capacity - but reliable and well tested) the Section had 35 seismic stations available. The GeoForschungsZentrum (GFZ) Potsdam brought 132 stations, some of them belonging to the University of Berlin, and the University of Copenhagen brought 5. With two stations put aside for shot timing, 170 were deployed on the profiles.

Profile A extended from the Old Head of Kinsale to near Black Head in Co. Clare, profile B from near Mizen Head in west Co. Cork to close to Kerry Head at the mouth of the Shannon. There

was also a short splay line, C, from the Kenmare river to Castleisland. With two deployments, and some stations being occupied for both deployments, a total of about 300 sites were used. The principal target of the project is the Variscan Front but the profiles also cross other features of great interest. These include the Iapetus Suture Zone, the Munster Basin and the Killarney gravity low. All are the subject of discussion and dispute as to their structure and development. An essential part of the project is that comparisons will be made with similar features in mainland Europe.

The site survey for the 300 VARNET Project recording sites was carried out in three phases, from 15 to 24 April, 28 April to 02 May, and from 08 to 20 May. K. Bolster visited all the sites with either C. Horan or D. Meghen.

Permission was sought from the owners of all sites. In general, landowners were helpful and gave permission readily, their main concerns being their cattle and silage crops. Finding good sites was made difficult due to the increase in the number of farmers using electric fences and in the number of drainage channels around the edges of fields. In some areas landowners were quite wary of strangers. This was understandable given the number of attacks on people in rural areas in early 1996, but it made the job of site surveying more difficult. Every Garda Station along the lines of the survey was visited. A circular had been sent out to all Superintendents beforehand and this explanatory circular and map was also handed out to owners of sites.

The project started with the setting up of a headquarters on 01 June in the Coastal Research Institute (CRI) of University College Cork. Facilities were kindly provided by A. Lewis, the Director of CRI. Equipment and staff arrived over the next few days and stations were tested in the grounds of the Institute. Fifteen two-person field parties, each with 10 to 12 stations, set out on 05 June. The ship was also available and started from the naval dockyard in Haulbowline (whose facilities are also gratefully acknowledged). The LOUGH BELTRA, with four scientific staff on board and G. Wallace as Chief Scientist, sailed on 07 June. The programme finished on 19 June, in spite of some early delays due to bad weather. Nearly 50 people were involved in the project in what was a very successful deployment.

Following the field work, M. Landes spent about two months in Potsdam processing data from the stations. He spent a further two weeks in the Universities of Copenhagen and Karlsruhe. He was assisted part of the time by F. Masson of the University of Karlsruhe. At the end of that period all the digital data had been processed. Only the records from the 20 analogue stations will have to be digitized later.

Preliminary interpretations in the last few months of the year gave some indications of the structures. There seem to be no large variations in the crustal thickness but there are significant variations within the crustal structure. It is too early to say more than that.

2.05 Transfrontier Seismological Project

A.W.B. Jacob, T.A. Blake and C. Horan with seismologists in nine other EU countries

Most of the EU earthquakes occur in the vicinity of the Mediterranean but, even in areas of low seismicity, sensitive industrial installations and high population density increase the risk (of damage and injury) where the hazard (the pattern of expected shaking) appears low. It may also be that apparently low hazard zones experience large events at very long intervals, sometimes too long to have a good historical record. In some areas it seems that the return period for large events may be thousands of years (the blink of an eye in geological terms). It thus makes sense to study in some detail the smaller events which occur quite frequently in quieter zones, looking for patterns in the events, and perhaps in the stress, tracing faults that are active.

The "Transfrontier" group of ten northern and western EU countries is supported by the Commission and has been working on the problems that arise when events fall in border areas and data from diverse sources must be collated. Tasks have included the installation of computer bulletin boards in each country, the development and/or adaptation of standard data exchange formats, especially for waveform data, the transmission of data continuously across borders where possible, and the upgrading of seismic networks in some areas where the coverage is not adequate.

The Geophysics Section was the host for a transfrontier meeting in Merrion Square on 26 April. Further consultations took place in Reykjavik in early September and a full meeting was held in Strasbourg on 17 and 18 October. This last meeting was originally to complete the final report but, since an extension has been

granted, this has been delayed until March 1997.

2.06 AIRS (Atlantic Irish Regional Survey) using GLORIA (Geological Long Range Inclined Asdic)

A.W.B. Jacob, P.W. Readman, J. Vermeulen and K. McGrane with R. Keary (GSI and Research Associate), P.M. Shannon (UCD and Research Associate) and Vikram Unnithan (UCD)

This is a collaborative project with the Geological Survey of Ireland and University College Dublin. The equipment, GLORIA, was made available through an EU contract with the Southampton Oceanography Centre under the Human Capital and Mobility Programme (Major Installations). The application, made in December 1995, was successful and a detailed feasibility study of the proposed project was made in the first three months of the year. Part of the feasibility study was to consult marine research groups in different parts of Ireland. A.W.B. Jacob, J. Vermeulen, R. Keary and P.M. Shannon conducted seminars on the GLORIA project in University College Galway (26 February), Geological Survey of Ireland (Dublin, 01 March), University College Cork (13 March) and the Fisheries Research Centre, Abbotstown, Dublin (19 March). This method is a new one for Geophysics projects but it meant that contributions from many different marine research interests could be taken into account when planning the research cruise later in the summer. Following the feasibility study, a report was presented to the Marine Institute at the end of March. This report, which concluded that it was a very worthwhile project, was to be the basis for a contract to complete the project.

The experimental part of the project, to map the deeper parts of the seafloor west of Ireland using the GLORIA instrument, began in August. The cruise covered approximately 200,000 square kilometres, mainly in the Rockall Trough, and in a small part of the Porcupine Seabight. The sonar image of the seabed obtained can be interpreted in terms of the nature of the seabed, e.g. rock outcrops, sediments etc. and structural features identified. A preliminary mosaic was prepared on board during the cruise with the help of Neil Kenyon from SOC. Many new features were identified including at least 15 submarine canyons and large mud slides, and a surprisingly large amount of rock outcrop was found on both flanks of the Trough. The work in the Porcupine Seabight identified and mapped a set of intriguing carbonate mounds, the origin of which is unknown as yet but about which there is considerable speculation and interest.

Following the cruise the two students working on the project (Keith McGrane and Vikram Unnithan) spent six weeks in Southampton producing a digital version of the mosaic and familiarising themselves with WHIPs (Woods Hole Image Processing System) and the ERDAS IMAGINE geographical information system, which form an integral part in the processing system.

GLORIA had been fitted with swath bathymetry for this cruise enabling bathymetry to be obtained over the width of the ground coverage of the instrument (approx. eight times the water depth). It was hoped that the accuracy would be of the order of 50m. The process of extracting the bathymetry is very complex and involves a lot of post-cruise processing. This process was started while McGrane and Unnithan were at Southampton and is being continued by the Gloria team.

Considerable difficulties with the bathymetry processing have been encountered, mainly because of environmental conditions in the area, including unusually high biological activity in the water, its complicated velocity depth structure (this was measured using probes during the cruise) and the low backscattered signal strength due to the large amounts of sediment cover on the bottom. In addition to GLORIA a 3.5 kHz sub-bottom profiler was deployed throughout the cruise which gave extremely detailed depth profiles along the cruise lines. Available data from other sources is also being analysed and will be used to create a 3-D image of the Rockall Trough with superimposed GLORIA images.

2.07 The Seismic Network (DNET, ENET and DSB)

T.A. Blake, C.M.Horan, D. Meghen, G. Wallace and A.W.B. Jacob

There were no onshore or near offshore events recorded in Ireland during the year. Significant UK events included an ML3.4 event in Shrewsbury, Shropshire on 07 March and an ML3.8 event near Penzance, Cornwall on 10 November. Large European events occurred on 09 October near Cyprus (Mb6.4, felt widely in the Middle East), 05 September in the Adriatic Sea (Mb5.6, felt in Dubrovnic, damage difficult to assess due to existing war damage) and on 15

October in Northern Italy (Mb5.3, also felt in Slovenia). There was an ML4.6 mining induced event in Germany on 11 September.

Elsewhere, the most damaging earthquakes occurred on 03 February in the Yannan Province, China (Mb6.3, over 250 people killed and another 4000 injured, some from subsequent rockslides) and on 12 November in Peru (Mb6.5, 14 people killed and another 600 injured). This event was felt in Ecuador and Bolivia. China carried out a nuclear test on 08 June, which was also recorded on the VARNET deployment (see below).

There were, as usual, a number of requests for general earthquake information from school-children working on projects and requests for more specific information from civil engineers. There were reports of possible local events by members of the public. Requests were received for information on the Lleyn event on 19 July 1984 and the Clonmany event (north Co. Donegal) on 21 November 1994. There were two requests for information on historic events by biographers attempting to locate their subject at a particular time. A Wexford newspaper requested information on the 05 September Adriatic event (the event was felt by Wexford people on pilgrimage to Medjugorje).

2.08 Land Gravity

P.W. Readman, B.M. O'Reilly and A. O'Brien

Southwest Ireland. The density of gravity measurements in parts of Counties Cork and Kerry is approximately one third to one half of that in most other parts of the country. A detailed set of gravity defined lineaments has been resolved over the major part of the country which often can be used in geological interpretation where no surface geology is visible. In the southwest however, little detail is seen and so features cannot be continued with confidence across the region. The lack of detail correlates exactly with the area where the measurement density is less. A programme of fieldwork has been started to increase the data coverage to that of the rest of the country. It is necessary to use differential GPS to obtain station elavations because much of the area is remote with few bench marks. The system has been checked and found to be accurate to the order of a few centimetres within a radius of 30 km from the base station, i.e. the accuracy is at least as good as would be obtained by using bench marks with the increased advantages of having more freedom in the location of the gravity measurement. This fieldwork will result in gravity interpretations and models which will test the seismic models from the VARNET project and provide the opportunity to make a joint interpretation.

Leinster Granite. In collaboration with P. Kennan of UCD additional gravity measurements are being obtained from the Leinster Granite in order to better define the anomaly. This forms part of a Ph.D. project to constrain the shape of the granite and hence help to formulate a model for its emplacement history.

2.09 Marine Satellite Gravity

P.W. Readman and B.M. O'Reilly

Detailed modelling of the long-wavelength component of the Marine Free Air Anomaly, obtained from a new analysis of satellite altimetry data, was completed along the RAPIDS profiles and out to the Mid-Atlantic Ridge (MAR). Plate models for the thermal structure of the lithosphere constrain the density structure beneath the Hatton Continental Margin and demonstrate the presence of a thermal anomaly westwards of the Rockall Bank which accounts for the seismic stratigraphic structure across the continental margin.

2.10 Palaeomagnetic Work (Late-Glacial Geomagnetic Field)

P.W. Readman with Niels Abrahamsen (University of Aarhus)

About 400 palaeomagnetic measurements on samples exposed in a cliff at the Late Glacial Allerød site at Nørre Lyngby in northern Jutland have been interpreted. Two profiles in the seven metres of sand, silt and gyttja, spanning a time interval between about 12 000 and 10 700 BP show about five cycles in the declination and about two cycles in the inclination. Features in the geomagnetic field observed at this site are also recognizable at sites in southern Sweden and Soviet Karelia. Comparisons with Holocene records indicate that the short time-scale behaviour of the geomagnetic field appears to have been similar since 14 000 BP, i.e. for a period considerably longer than the timescale of the variations themselves, suggestive that this type of behaviour is a permanent feature of the geomagnetic field. These secular variations may be useful for future local as well as more regional stratigraphical correlations in the Late Glacial and Holocene.

3 Research Activities in the Astronomy Section

3.01 Highly X-ray Luminous IRAS Galaxies

E.J.A. Meurs and L. Norci with M. Carr (TCD)

Several galaxies from the IRAS Point Source Catalog had turned out to emit abnormally high X-ray luminosities for non-active galaxies, when examined in ROSAT All Sky Survey data. Further investigations were carried out with archival ROSAT PSPC data for a number of these objects, yielding evidence that hidden active nuclei may not be the explanation for their copious X-ray emission.

A comparison of these X-ray luminous IRAS galaxies with proper AGNs, using ROSAT X-ray data, was carried out. A potentially interesting difference between the two main types of Seyfert galaxies and the less active Liner galaxies was investigated further. The increasing size of the X-ray sources associated with these galaxy types is of importance to considerations regarding unified models of AGNs.

3.02 Spectroscopy of Active Galaxy Candidates

E.J.A. Meurs and L. Nazarova

The analysis of a set of medium resolution optical spectra of galaxies from the Case Survey progressed to near completion. These galaxies generally exhibit emission lines in their spectrum and several of them turn out to be active galaxies. Their classification is assessed on the basis of line widths and line ratios. The results of this work will be used to evaluate the active galaxy content of the Case survey and to provide further information on the ratio at which the two main subtypes of active nuclei occur.

3.03 Application of Voronoi tessellations in Astrophysics

M. Wilkinson and E.J.A. Meurs

An M.Sc. project was completed in which two applications of the so-called Voronoi tessellations in astrophysics are examined. This mathematical procedure provides a unique partitioning of space around objects or events, so that only one point of a given distribution (e.g. galaxies or photon events) is contained in each Voronoi cell. The main aspect of this technique that was investigated is how much information about the shape of a concentrated collection of points (such as photons constituting a source, or galaxies in large-scale filaments) can be recovered from a given 2-dimensional distribution of points. This was first of all pursued for simulated, elliptically shaped photon sources. The high degree of success in retrieving these source shapes prompted a pilot attempt to find in the same way a description for the filamentary structure in the large-scale distribution of galaxies. Interesting results were obtained for the well-known CfA redshift survey data. In a complementary effort, the large-scale structure connecting main galaxy clusters was examined in the framework of an overall, Voronoi-like construction of the Universe around us.

3.04 Searching for Active Cores in Local Group Galaxies

Z. Zang and E.J.A. Meurs

To investigate the occurrence of nuclear activity in galaxies to the lowest possible levels, we have been searching for central sources in other galaxies of the Local Group around the Milky Way system, with data from the ROSAT HRI (High Resolution Imager). These galaxies are the nearest specimen of stellar systems and can be examined to lower levels of X-ray emission than any other galaxies. The X-ray regime of the spectrum is expected to be particularly relevant for recognising even weak signs of any nuclear activity. It is of great interest to investigate whether the smaller members of the Local Group might also harbour an active core in their centres. The data are available from the ROSAT Archive and allow work on the Local Group members with absolute magnitudes less than -14.5; some PSPC data are also examined in addition, to complement the information.

3.05 High-energy Studies of Star Forming Regions in an Extragalactic Context

L. Norci and E.J.A. Meurs

Many forms of star forming regions are encountered among the extragalactic objects. Recently it has become possible to study such regions at X-rays with appreciable spatial and spectral resolution. At these high energies interesting information can be obtained about the evolving stellar population and its interaction with the ambient Interstellar Medium. A novel

approach to interpret such data is to develop a population synthesis computer programme that monitors the X-ray active phases for each individual star (and each binary) while the stellar population evolves.

In an EU supported TMR project, some time was first devoted to observational studies of relevant star forming regions (Berkeley 87; 30 Doradus; IRAS galaxies). Then a first stage of the actual population synthesis programme was conceived and implemented, allowing a population of single stars (for various conditions for the star forming process) to be followed during their evolution. For this purpose, the latest stellar evolution scenarios were incorporated.

3.06 Peripheral Cluster Gas and Tailed Radio Sources

L. Norci and E.J.A. Meurs with L. Feretti (IRA, Bologna) and D. Mahon (TCD)

The study of the X-ray morphology of the galaxy cluster A2241 progressed during the year. The radial brightness distribution of the intracluster gas was modelled with a standard King profile, for which purpose several fitting routines were written. The resulting profile, obtained on the basis of the brightness data outside the innermost region of A2241, shows clear evidence for a source associated with the central dominant galaxy, superimposed on the overall emission from the diffuse intracluster gas. With this work the cluster gas brightness distribution is much better determined and the measurements of other sources in the field can be corrected properly for the effects of the diffuse cluster emission. These include a couple of galaxies with radio tails, for which the X-ray results will allow the physical state of peripheral cluster gas to be inferred.

3.07 ROSAT Survey: The Einstein EMSS Galaxy Clusters

L. Norci with H. Böhringer, R. Treumann, W. Voges (MPE, Garching) and H. Ebeling (Hawaii)

During the Einstein X-ray satellite Extended Medium Sensitivity Survey 835 serendipitous sources have been detected, of which 105 were recognised as clusters of galaxies. The ROSAT All Sky Survey offers for the first time the opportunity of a direct evaluation of the extension and shape of the X-ray emitting region. It is indeed possible to define, within the survey limits, the source extension and to carry out a sensible measurement of the background contribution. In particular, the EMSS cluster sample contains several distant clusters with low brightness distributions for which the definition of extension and background are crucial for flux determination. Suitably sized 40x40 arcmin regions around each EMSS cluster have been extracted from the ROSAT All Sky Survey. The morphology of these clusters has been studied and the energy flux and luminosity in various extraction regions for the whole EMSS cluster sample has been calculated.

3.08 A ROSAT HRI Observation of the Cluster MS0353-7411 (A3186)

L. Norci with R. Nesci (Istituto Astronomico Universitá di Roma)

Cooling flows have been observed in massive galaxies, groups and clusters of galaxies. The central regions of such massive objects reach, as a result of the gravitational contraction, temperatures of the order of several million degrees. In such a situation matter flows towards the center of the system because of the weight of the overlying gas. Such cooling phenomena are directly observed only in the X-ray wavelength region. The cluster MS 0353-7411 (A3186) was observed with the high resolution imager of the ROSAT satellite. Work on the detailed cluster morphology was carried on in order to assess the presence of a cooling flow and to determine relevant physical parameters.

3.09 Studies of WO Stars

L. Norci with V.F. Polcaro, R. Viotti (IAS, Frascati) and C. Rossi (Istituto Astronomico Universitá di Roma)

The WO spectral type was first introduced to classify a small group of nuclei of Planetary Nebulae (PNN) showing a Wolf-Rayet-type spectrum with strong O VI 381.1-383.4 nm emission. Subsequently the "Population I WO" spectral class was introduced to indicate a group of a few, extreme, massive WR stars having similar spectral signatures and very high wind velocity and mass loss. Only six "Pop I WO" stars are known to date in the Local Group (three in our Galaxy, one in LMC, one in SMC and one in IC1613). This small number is a clear indication of the short time spent in this phase which, according to current models, is believed to be the

latest evolutionary stage of very high mass stars (initial mass about 40 solar masses).

A spectroscopic study of the planetary nebula NGC 5189 (PK 307 -3°1) with its O VI sequence central object has been carried out, with the aim of identifying differences between population II and population I objects. The intention of this study is to solve the difficult issue of the exact evolutionary phase of the WO Wolf-Rayet stars.

The WR star Sand 5 (WR 142) is the nearest and less studied member of the small WO subgroup, located in the peculiar open cluster Berkeley 87. Detailed spectroscopy of the star was carried out in order to study further the controversial evolutionary status of the WO stars and to assess the influence of this object within the Berkeley 87 cluster.

3.10 V439 Cyg, the Red Star that became Blue

L. Norci with V.F. Polcaro (IAS, Frascati)

Most of the members of the peculiar open cluster Berkeley 87 are young, heavily reddened OB stars. A few are however much more evolved objects, such as the WO star Sand 5 and the M3.5I variable BC Cyg. This evidence exemplifies the extremely uncertain evolutionary status of the cluster. Berkeley 87 is probably part of the star forming region ON2, where many compact H II regions, strong OH masers and CO and ammonia molecular clouds have been detected. Two strong IRAS sources are present, one coincident with BC Cyg and the other one situated near the apparent cluster centre, as is diffuse far-infrared emission.

One peculiar cluster member is an emission line star known as V439 Cyg or MWC 1015. This star dramatically changed its spectrum from late to early type in only a few decades. Furthermore, some absorption lines that were still present in optical spectra taken in 1986 and 1987 disappeared completely since 1988. The star is characterized by a strong IR excess and a peculiar position in the HR diagram (depicting luminosity against temperature). New spectroscopic data on this unique object have been obtained and are currently being analysed.

3.11 Lightcurves of bright RR-Lyrae stars

R. White with A.A. Henden (Flagstaff Observatory, Arizona, USA)

As background to the on-going observations, archived photometry of the programme stars (general field RR Lyrae variable stars) was collected and assembled into a database for each one. The database will be used to determine long-range variations in the stars' light-curves and periods.

3.12 Radial distribution of RR Lyrae stars in Globular Star Clusters

R. White

Basic data for this project come from published radial density distributions (from star-counts by King et al. and by Peterson) for sixteen globular clusters, which possess a sufficient amount of member RR Lyrae-type variable stars. The information on the variable stars is from C.C. Clement, University of Toronto, continuing the work begun by the late H.S. Hogg. All of the variable star data have been compiled and reduced, after which their density profiles have been compared with those for the overall stellar distributions for the globular clusters. It appears that the collapsed-core clusters are readily seen when this comparison is made.

3.13 Optical Monitoring Camera (OMC) for the INTEGRAL mission

B.D. Jordan, M. Smyth and E.J.A. Meurs with B. McBreen and M. Delaney (UCD) and D. Walton (MSSL)

The programme of development of the Optical Monitoring Camera for INTEGRAL continued throughout the year. At the end of the year, Mullard Space Science Laboratory rejoined the OMC consortium with funding from PPARC (UK), with responsibility for procuring and testing the CCD and Focal Plane Assembly. The final specification of the baseline CCD was agreed with ESTEC and a contract for the CCD was awarded to EEV (Chelmsford, UK). The Laboratory Model was largely completed but due to the delay with the CCD procurement it was configured for use with a medium array detector in order that software development could proceed.

The design of the subsequent OMC Engineering Model is well advanced. The OMC spacecraft computer interfaces are now well defined and a 12-bit Analog to Digital Converter for the detector has been completed. A scientific requirement for on-chip windowing of the detected image was

identified and it was agreed that this facility would be provided on the Engineering Model. A novel scheme incorporating a Static Random Access Memory chip to provide a map of the CCD array was devised so that windows of the on-chip image can be addressed and the image read out in such a manner that only the windows defined in the SRAM are processed. However, this scheme proved to be too complex to implement using the conservative technology imposed by the currently available range of space qualified active components. A new design using electronic programmable counters is now being implemented.

3.14 Position Sensitive Diode Detector

B.D. Jordan and M. Smyth with M. O'Colhoun (UCG) and P. Read (DRAL)

The Position Sensitive Diode system was completed early in the year. After final testing and further software development at UCG the equipment was transferred to DRAL (UK) where a Micro Channel Plate intensifier will be fitted to the diode detector and the complete system will be evaluated for its suitability as a general purpose photon counting imaging system.

4 Research Activities in the Astrophysics Section

4.01 Interstellar Dust and the Galactic Cosmic Rays

L.O'C. Drury with D. Ellison (NCSU) and J.-P. Meyer (CEA, Saclay)

A new theoretical model capable of explaining the composition of the Galactic cosmic rays was worked out in some detail. The key new concept is to apply modern shock acceleration theory to interstellar dust grains interacting with a supernova shock. The grains have a small electric charge and will be accelerated as if they were very massive ions. This acceleration will be limited by the frictional drag of the grains against the background gas to a relatively modest amount; typically grains can have their velocities increased relative to the gas by a factor of at most about ten. This is however enough to give a significant amount of sputtering of ions off the grain surface while the grains are in the region upstream of the shock. These ions are created at suprathermal velocities and will be very efficiently accelerated on subsequent advection into the shock. The mixture of these sputtered ions of refractory elements, and ions directly injected from the gas phase, appears to give a very natural and quantitatively correct description of the compositional data.

4.02 Fusion Plasma Theory

L.O'C. Drury with DCU, UCC, CEC and Culham

In magnetically confined fusion experiments, most notably the Joint European Torus, plasmas are now routinely created in which significant non-thermal populations are present. The physical problems of plasma instabilties and particle transport in such systems are very similar to those discussed in the context of cosmic ray acceleration and transport theory. Following extensive consultation an Irish Fusion Association was established comprising teams from DCU, UCC and DIAS. The association's work will be part-funded under the Fusion Energy Programme of the CEC.

4.03 The Ultra Heavy Cosmic Ray Experiment (UHCRE) on the LDEF Mission

A. Thompson, D. O'Sullivan, L.O'C. Drury and A.J. Keane with K.-P. Wenzel (ESTEC)

New direct calibrations, temperature controlled, of LDEF-UHCRE flight spare and flight retrieved detector polycarbonate with 2.0 and 4.0 A GeV gold ions (Z=79) were successfully carried out at Brookhaven National Laboratory (BNL), New York, during January. Exposure temperatures over a wide range were employed, spanning the temperature extremes reached by the detectors in Earth orbit. Later in the year, a further calibration exposure was implemented, employing a beam of 1.2 A GeV (nominal) uranium ions (Z=92) at GSI, Darmstadt. In this case the beam was brought to rest within the detector stack, providing a spectrum of lower energies which could be explicitly determined by direct residual range measurement from stopping points. Inter alia, this allowed direct comparison with lower energy (<960 A MeV) preflight and postflight uranium ions in the same polycarbonate detector plates.

During the year a programme of selecting and etching detector plates for multiple cross calibration was iniated. The intention is to derive retrospective correction factors for small

systematic differences in signal from etch to etch in previously etched UHCRE material, employing 10.5 A GeV gold ions (via BNL exposures) to provide a basic reference value of ionisation. In parallel with UHCRE detector etching, a systematic experimental investigation of etching conditions for relativistic ultra heavy ions was carried out. It was observed that the unnormalised signal strength (VT) for a given ionisation rate remained constant over a wide range of concentration of etch byproducts. Subsequently it was found that using VT as a parameter for deriving the UHCRE charge spectrum appeared to improve resolution at the actinide gap, thus raising a question concerning the normalising factor (VG) and providing further justification for cross calibration, as above.

Having analysed all of the ultra heavy cosmic ray events from about 35% of the accessible UHCRE collecting area it was decided to switch to a programme for the extraction of actinides from the remainder of the accessible collecting area by means of an "actinide skim" procedure. The bulk of the new etching and all of the new ammonia scanning required for the actinide skim were completed by December with extraction scheduled to begin in January 1997. The current UHCRE values for the lead to platinum ratio and for the actinide to subactinide ratio stand at 0.289±0.027 and 0.023±0.006 respectively.

4.04 The Production of Jets from Young Stars

S. O'Sullivan, A. Scally, T.P. Ray and L.O'C. Drury

The most popular models for protostellar jet production invoke magnetohydrodynamic (MHD) phenomena in the partially ionised gas around the star and are similar in many aspects to models for the production of extragalactic radio jets. These models may be sufficient to account for the existence of jets in the steady state, but there is much scope for further understanding of the time evolution of the system – both in its formation and in its influence on the circumstellar disk. The question of stability is also unresolved.

To date a new numerical code has been written to solve the ideal MHD equations in two dimensions. It is based on an explicit finite difference method using an Eulerian grid, known as the total variation diminishing (TVD) scheme. This is a second-order accurate extension of the Roe-type upwind scheme. It is improved by using source terms to maintain zero divergence in the magnetic field by effectively introducing a so-called divergence wave. The inclusion of artificial off-diagonal viscous stress tensor elements removes unphysical distortions due to the anisotropy of the dissipative truncation error terms. This code has now been rigorously tested. A two-dimensional second-order accurate Riemann solver has also been written which handles the direction of the transverse magnetic field in a consistent manner.

Work has begun on producing a hierarchical adaptive grid driver in parallelized C++ which will save computation time in regions of low interest and give improved resolution elsewhere. Once this has been completed, cooling functions will be included and the disk regions around young stars which are thought to produce jets will be modeled. This is of particular interest as, to date, no high resolution simulations of MHD jet formation have been done which include radiative losses. A fundamental question is whether one can simulate the production of, not only the observed highly collimated jets, but their coupling with slow diffuse winds that may derive from the disk's corona.

In parallel with the development of the new DIAS MHD code, the production of jets from circumstellar disks is also being investigated using the ZEUS-2D astrophysical MHD code developed by the National Center for Supercomputer Applications in the U.S. In part this work builds on previous simulations but using the faster and more sophisticated computational resources now available. Its particular focus is to study the formation of large azimuthal magnetic fields in the vicinity of the disk through differential rotation. This process is thought to lead to the ejection of material from the disk through the release of magnetic energy and the collimation of a jet. The simulation will be run for much longer timescales than in previous work, to see if the hypothesized steady state is actually achieved, and if so, to probe its stability. To date, the ZEUS-2D code has been successfully installed; it is now being run on a range of test problems (such as, for example, the growth of a spherical blast in a magnetised medium). Once testing has been completed, it will be possible to configure the code for the MHD jet problem.

4.05 Simulations of Jets from Young Stars

T. Downes, T.P. Ray and L.O'C. Drury

During the year, a new, second order accurate, slab symmetric, hydrodynamic code was finished and

tested. This code incorporates the effects of radiative cooling, ionization and the presence of molecular hydrogen in the gas being simulated. Several simulations of jets from young stellar objects were run and predicted line profiles, emission maps, and total intensities in specific lines were calculated. Such a simulation, with initial conditions chosen to approximate the conditions inferred from observations in the Herbig-Haro 46/47 outflow, was found to reproduce observations remarkably well. In particular, the total intensity derived from this simulation in the S(1) υ = 1-0 line of shocked molecular hydrogen was found to be within a factor of three of that which is observed.

In addition, a numerical study of the influence of cooling on the Kelvin-Helmholtz instability was undertaken. It has been speculated by the group that such instabilities, driven by the shear between the jet and its external medium, may be responsible for some of the knot like structures seen in young stellar object jets. Given the importance of radiative cooling in these jets, its effects must be allowed for. It was found that, while the linear growth rates of the body modes of this instability were not significantly affected by cooling under typical jet conditions, the non-linear behaviour of the instability differed considerably from the adiabatic case. Indeed, the presence of cooling tended to reduce the time taken from initiation of the instability to disruption of the jet. Different cooling functions were investigated to see if this behaviour was critically dependent on the precise behaviour of cooling with temperature. It was found that, once cooling was present, the jet disrupted sooner than the adiabatic case. The precise time taken to disrupt does, however, seem to depend on the form of the cooling function.

4.06 Investigation of Cosmic Rays at Aviation Altitudes (IRMA-2)

D. O'Sullivan, J. Donnelly, E. Flood, R. Keegan and D. Zhou

A new contract, successfully negotiated with the CEC, involving DIAS and eight European laboratories, with D. O'Sullivan as scientific co-ordinator commenced on 01 January. Measurements of cosmic rays and their secondaries at aviation altitudes were greatly extended during the year. Data have now been accumulated for very long periods (up to 2000hrs) on several subsonic routes and on a supersonic route between London and New York. The work has been extended to include the Rome / Los Angeles and Rome / Rio de Janeiro route through the courtesy of Alitalia.

The original objective of determining the relative abundances of Z > 1 nuclei at these altitudes has been extended to include investigations of the linear energy transfer (LET) distributions also. Work on the relative abundances concentrated mainly on the subsonic exposures where earlier work of the group had shown the presence of elements He, Li and Be. Linear energy transfer studies have given initial spectra for a Concorde flight route and subsonic Dublin / New York and Rome / Los Angeles routes. The preliminary data show that the integral flux is approximately three times greater on the supersonic than on the subsonic exposures. The relatively small difference is probably due to the fact that the Concorde flies just above the Pfotzer maximum in the atmosphere and the subsonic craft fly just below it. Interpretation of the data in terms of human dose equivalent is in progress. Calibration of detectors continued with exposure to 80 MeV/N carbon nuclei at GSI, Darmstadt.

In December, Aer Lingus agreed to install a small exposure platform on one of their airbuses. The new arrangement will provide fourteen different exposure angles for a detailed investigation of angular distribution effects.

4.07 Near-IR and mm Observations of Molecular Outflows from Young Stars

C.J. Davis and T.P. Ray

In an attempt to identify the shocks associated with the entrainment of ambient molecular gas by collimated jets, the star formation group have imaged a number of outflows in the near-infrared. The H_2 v=1-O S(l) line has been used as probe of the low-excitation shocks that are generated as the flow impinges on its surroundings. A comparison of these data with published carbon monoxide outflow maps and new optical images has led to a better understanding of many of the outflows observed. In particular, it is seen that the peaks in the molecular "CO" outflow maps are associated with H_2 bow shocks in the majority of our targets. This suggests that the bulk of the molecular material in CO flows is in fact swept up ambient gas, accelerated in bow shocks which form at the head of, and along the length of, a collimated jet. This mechanism is known as "prompt entrainment" and is favoured over the steady-state, or "turbulent" entrainment mechanism for jet-driven molecular outflows.

A second way in which one can distinguish between entrainment models is by measuring the momentum per unit length at intervals along CO outflows. In the turbulent entrainment model (in which ambient gas is entrained in a mixing layer along the length of the jet) this quantity should increase with distance from the source. Conversely, in the prompt entrainment model, the momentum decreases with distance from the source as the flow "accelerates" into the lower density regions further out. To this end, a fully-sampled CO map of the outflow RNO 15-FIR has been obtained. On-going analysis of the data again suggests that the prompt entrainment mechanism dominates.

The importance of bow shocks in outflows from young stars is apparent in many recently acquired infrared images. Bow shocks form at the head of collimated jets and along the length of jets that exhibit an episodic flow velocity. Yet the physics behind these shocks is still poorly understood, and is very much a subject of debate at the moment. Many bow shocks in YSO jets are seen in H_2 emission. The H_2 is excited in the wings of the bow, where the molecules survive the passage of the shock due to the oblique shock angles. Nearer the head of the bow, the gas is ionised, so the head is usually observed in the forbidden lines of ions such as [SII] and [FeII]. However, it is still not known whether the shocks are Jump/J-type or Continuous/C-type. In other words, what role, if any, do magnetic fields play? To better understand the shocks in YSO outflows one must examine both the excitation and the kinematics. The star formation group have recently imaged the well-known OMC-1 outflow, and the flow from the very young source Cep E, in a number of different H_2 lines. With these data, they have been able to map temperature and excitation conditions across each region, and so distinguish shock types and at the same time search for evidence of non-thermal excitation processes. Moreover, their H_2 υ=3-2 S(3) image of Cep E is the first of its kind in any region. It is hoped to image the well known HH 46/47 outflow region soon and to extend the analysis of shock-physics to planetary nebulae.

4.08 The Infrared Space Observatory (ISO)

L.O'C. Drury, T.P. Ray, S.C. Russell and W.-M. Tai

Results from ISO observations, in particular from ISOPHOT, have poured in over the year. Preliminary analysis of the data from the guaranteed time observations of Bok Globules, has revealed exciting new details of low mass star formation in these isolated clouds. Observations made as part of the ISO photometer (ISOPHOT) Core Programme were analysed to check for evidence of disks around weak-line T Tauri stars, i.e. young stars with weak hydrogen emission. Although there is a large body of both indirect and, more recently with the Hubble Space Telescope, direct evidence for disks around classical T Tauri stars, it was not clear whether their counterparts with weaker line emission are likewise surrounded by circumstellar matter. Although the precursor to ISO, the Infrared Astronomical Satellite (IRAS) placed limits upon the amounts of dust present, these were not very stringent. Analysis of the ISOPHOT data, however, has shown that a number of weak-line T Tauri stars are undoubtedly surrounded by circumstellar matter. Rather interestingly much of the excess infrared emission appears longward of 10 microns and at a level just below the detection threshold of IRAS. The spectral energy distribution of these stars is therefore essentially photospheric with an additional contribution which may arise from a disk component but at distances greater than 1.0 AU, i.e. a disk may be present but with an inner hole possibly due to planetary formation.

Analysis of ISOPHOT data continued to be based almost exclusively on the use of the Interactive Analysis software suite to which W-M Tai made substantial contributions during the year.

4.09 Magnetic Fields in Outflows

T.P. Ray, T. Muxlow (Jodrell Bank), D. Axon (Space Telescope Science Institute, Baltimore), A. Brown (University of Colorado), D. Corcoran (University of Limerick) and J. Dyson (University of Leeds)

While it is generally agreed that magnetic fields are responsible for collimating outflows from young stars and also for mediating their accretion, surprisingly there is no direct evidence for their presence in outflows. Thus there was considerable interest when the first direct observations of a magnetic field in an outflow using radio techniques was made by the above collaboration, with T.P. Ray as principal investigator. The observations, at a frequency of 5 GHz, were of the well known young star T Tauri and used the Multi-Element Radio Linked Interferometer Network (MERLIN) centred on Jodrell Bank. Three radio sources were detected within an area of diameter 0".7; the northern source T Tau N,

was found to correspond to the well known optical star while the more southern one, T Tau S, aligned with its known infrared companion. The radio emission from T Tau S was found to be extended and its direction clearly implicated it as the source of the large scale outflows (with sizes of several light years) recently found in the vicinity of T Tau. More importantly the radio emission was discovered to be circularly polarised with the two sides of the flow having opposite helicity. Not only is this the first such observation of extended polarisation in an outflow but it clearly implies the presence of magnetic fields. The only viable mechanism to produce such emissions is gyrosynchrotron radiation from mildly relativistic electrons. An estimate of the field strength in the outflow, at distances of about 10 astronomical units (AU) from the star, can be made based on these observations; typical values found are around a few gauss. Such values appear very high unless they represent advected fields with at most an inverse radial decrease in strength compared to surface values. Moreover, field amplification, through highly compressive radiative shocks, may also play a role. Such shocks could also be responsible for accelerating the emitting electrons to the desired energies.

4.10 Nuclear Track Detector Response Studies

A. Thompson, D. O'Sullivan and A.J. Keane

During January an extensive programme of solid state nuclear track detector (SSNTD) exposures was successfully implemented at the Brookhaven National Laboratory (BNL), New York, heavy ion accelerator facility. This work involved multiple exposures of five temperature controlled polycarbonate detector stacks to relativistic gold ions (Z=79) with beam energies of 2.0 and 4.0 A GeV. Continuous energy coverage from 1.0 to 4.0 A GeV within one stack was obtained by means of an interlaced distribution of lead velocity degraders and electron strippers. All five stacks, which had been previously (December 1995) exposed to 10.5 A GeV gold ions, employed several batches of detector polycarbonate including LDEF-UHCRE flight spare components and also flight retrieved components. A range of exposure temperatures from -78°C to +22°C was employed and the integrated ion exposure density was reduced, in each case, to about 200 cm^{-2} via beam defocusing. The primary objective of this work is to investigate the track response variation of polycarbonate to ultra heavy nuclei in the neighbourhood of the relativistic rise of ionisation and to determine the associated temperature dependence of signal strength. The bulk of the required detector etching and track measurement was carried out during the year and initial results obtained by the end of the year.

A composite BP-1 glass and polycarbonate detector stack was exposed to 4.0 A GeV gold ions at BNL, also during January, in collaboration with Berkeley Physics Department (University of California) in order to investigate charge discrimination and comparative resolution in the two detector materials. Beam interactions within the stack provided a spectrum of ions with nuclear charge less than that of gold. Initial results from track analysis during the year indicated an intrinsic charge resolution under the given experimental conditions of 0.4e for polycarbonate in the platinum (Z=78) region. Other results during the year included (I) a confirmation of the isotropy of track response to relativistic ultra heavy nuclei in polycarbonate at a higher level of precision and a wider range of zenith than hitherto and (II) the conclusion that the track response to relativistic ultra heavy nuclei in polycarbonate is batch independent (for the given batches) within experimental error and, in particular, that no variation of sensitivity with age could be detected. Apart from its inherent value, all of the above work is relevant to optimisation of charge spectrum resolution in the DIAS/ESTEC Ultra Heavy Cosmic Ray Experiment (UHCRE).

During November, exposures of two SSNTD stacks to 1.2 A GeV (nominal) uranium ion beams (Z=92) were successfully carried out at GSI (Gesellschaft für Schwerionenforschung mbH), Darmstadt. The first stack, which employed 300 polycarbonate elements interlaced with BP-1 glass, was designed to further the joint study with Berkeley of detector resolution. The second stack featured 380 polycarbonate plates, including some which had been previously exposed to 2.0, 4.0 and 10.5 A GeV gold ions. The stopping power of this stack was 16.1 g cm^{-2} at $\pi/4$ incidence, sufficient to bring the uranium ions to rest. Scientific objectives are, inter alia, to test and develop the track response/ionisation model and the charge assignment software in extended regions of charge/energy and to investigate latent track stability in the given ionisation regions over an extended time base.

4.11 Slow Evolution of Shock Structures

K. Farrell and L.O'C. Drury

A new, explicit, adaptive grid method for use in the solution of one-dimensional initial-value problems has been developed. The method is

based on the concept of tracking and resolving individual features of the physical solution. Properties of these real features are used to construct an artificial resolution function corresponding to a finite number of artificial features, each of which is then used to track a real feature. The artificial resolution function is constructed in such a way that it is analytically integrable, which allows a very stable and simple grid generation. Moving the artificial features is much more straightforward than trying to move the grid-points directly; although, the latter has been demonstrated to work well for stationary shocks. Features which interact or even move off the grid can be treated without affecting grid-monotonicity. Tracking of features is essentially instantaneous, whilst they are resolved fully over a number of time-steps.

It is intended to increase the level of sophistication within this method. In order to deal more adequately with the interaction of features, improved matching of artificial to real features is necessary. A way of distinguishing between contact-discontinuities and shocks will be the first of these modificiations, followed by improved tracking. The problem of resolving spurious features in the numerical solution can probably be dealt with in this context, but may also be improved in other ways (see below).

The new grid method has been implemented successfully with the existing first- and second-order accurate flux-vector splitting hydrodynamics scheme. Another (less noisy) hydrodynamics scheme is currently being developed to improve upon the present one. It is hoped to incorporate the particle-acceleration effects once this has been completed.

4.12 Abundance Studies

S.C. Russell

Research has been carried out on the problem of why RV Tau variables, and stars like them, have s-process underabundances similar to those found in extreme halo red giants. Two possibilities present themselves: either these stars represent extreme halo stars themselves, with hydrogen deficient atmospheres; or they have been over ionized by shock waves in their atmospheres. To select one of these scenarios, high resolution spectra were obtained of these stars in globular clusters, together with several "normal" giant stars in the same clusters. A comparison between RV Tau variables and the normal giants should have revealed which of the two hypotheses was correct. It turned out that RV Tau variables in the three globular clusters studied failed to show the effect seen in field variables. It is supposed that this is because of their low metallicity.

5 Facilities

5.1 Computers

5.1.1 Merrion Square

There were two significant developments during the year. Firstly, all the general service computers and communication equipment were moved into a specially adapted room in the basement thereby releasing valuable office space and simplifying administration of the system. Secondly, towards the end of the year it was decided to start the construction of an experimental system for parallel processing based on standard PC components. The configuration eventually chosen comprises twelve 200MHz PentiumPro processors, mounted on six dual processor motherboards each with 256MB of memory. The six units communicate over fast ethernet interfaces. Two scholars (T. Downes and S. O'Sullivan) participated in a virtual workshop on parallel processing run by the Cornell Theory Center in preparation for using this system.

A CD-ROM writer was installed to facilitate the creation of reliable backups. The device will be used, inter alia, for archiving the many scientific databases already held in the three Sections. The Geophysics Section WWW Home Page was restructured and expanded.

5.1.2 Dunsink Observatory

At Dunsink, the main 4GB disk drive had to be replaced after a disk crash. A Gateway multi-media computer was included in the Dunsink LAN.

5.2 Geophysics Instruments

After extensive testing of the fifteen new digital seismic recorders (Type PR2400, manufactured by Earth Data Ltd) the equipment had its first field deployment during the VARNET project and a little later during the second COMBO project in

Portugal. Overall the recorders worked very well and proved to be robust in damp cool conditions as well as in extreme heat. The only serious problem is precise internal timing if the recorder loses its GPS lock.

A number of stations on the network were down for significant periods during the year. This is partly due to the advanced age of much of the equipment.

5.3 Nuclear Track Equipment

Track measurement and scanning units were re-installed in Track Lab #1 during January following completion of roof repairs. The six Leitz-ASL track measuring microscope stations, the Nikon-Heidenhain track measuring microscope station and the six Nikon stereo scanning microscope systems were maintained and upgraded as necessary during the year. In particular, reconditioned illumination systems were fitted to two of the Leitz-ASL stations. The ammonia scanning facility in Track Lab #3 was refurbished and used extensively during the year.

The three main track detector etching tanks (150 litre capacity each) and associated equipment were also maintained throughout the year and repaired as necessary. Replacement sub-systems or components included new improved high precision temperature control units (fitted to Etch Tank #1 and Etch Tank #3) and a new drive system, new bearings and reconditioned motor (fitted to Etch Tank #2). A new track detector wash system with collimated water supply was developed and set up in the Etching Lab along with a refurbished pumping system for sodium hydroxide solutions. In addition, a new PC based multichannel temperature monitoring and archiving system for the three main etching tanks was installed in the Detector Preparation Lab to operate in parallel with the primary temperature recording system. The temperature stability of these tanks continues to be better than ± 0.005 °C.

5.4 La Palma Observatory

T.P. Ray (Secretary)

5.4.1 General

R.M. Redfern (UCG) attended the Panel for Allocation of Telescope Time (PATT) committee meetings in June and December in Stratford upon Avon as the Irish representative. As the La Palma Observatory has been approved for funding under the Large Scale Facilities scheme within the EU Training and Mobility of Researchers (TMR) programme, it now transpires that costs on the island will in future be met by the Instituto de Astrofisica Canarias (IAC) for Irish astronomers who are not using the Jacobus Kapteyn Telescope. The latter telescope is excluded from TMR funding on the grounds that Ireland contributed to its capital costs.

Recognizing the importance of access to the La Palma Observatory and other Particle Physics and Astronomy Research Council groundbased facilities by Ireland, Forbairt is now providing, through the Measure Four Programme, an annual subvention for the travel and subsistence expenses of non-DIAS observers.

T.P. Ray continued to produce a twice yearly information bulletin (in March and September) to keep the community informed of changes in PATT procedures, PATT deadlines and other useful items of information.

5.4.2 Observing Runs Carried Out in 1996

Runs are listed alphabetically according to the name of the principal applicant. The PATT reference numbers, where applicable, are also given. Non-PATT observing runs, supported by DIAS, are also noted.

P. Callanan (UCC): *J, H and K Band Spectroscopy and Photometry of Bright Low Mass X-ray Binaries*, Shane (3m) Telescope using the UCLA Gemini Twin Beam IR detector, Mount Hamilton, three nights. Only one night was clear during which an attempt was made to measure the ellipsoidal lightcurve of GRO J0422+32 in H and K. These data are currently being analyzed. The work is in collaboration with Harvard, Berkeley, and UCLA.

C.J. Davis and T.P. Ray (DIAS): (A/96A/06) *Search for H_2 Jets and Flows from the Youngest Stars in Ophiuchus*, Anglo Australian Telescope, four nights. Surprisingly no evidence of shocked molecular hydrogen features was found around any of the original targets. However, a number of other flows were observed that were known to be bright in shocked molecular hydrogen and these data were used to complement other projects including a detailed study of the flows in the vicinity of the dark cloud Lynds 1660.

C.J. Davis and T.P. Ray (DIAS): (M/96A/19) *Jet Driven Molecular Outflows: Prompt or Steady*

State Entrainment?, James Clark Maxwell Telescope, two shifts. A fully-sampled CO 3-2 map of the bipolar outflow associated with RNO 15-FIR was obtained. This molecular outflow was found to be very interesting in that it is unusually highly collimated and appears to be "wiggling". On-going analysis of the data clearly points to prompt entrainment (i.e. entrainment at the head of these flows) being responsible for molecular outflows.

A.M. Redfern, A. Shearer et al. (UCG): *Optical Pulsations of the Gamma Ray Pulsar Geminga*, SAO (Zelenchuk Observatory) Six Meter Telescope, four nights. This run, which occurred towards the end of January, was highly successful. Although awarded four nights to observe the gamma ray pulsar Geminga, the UCG group were given the use of the dark periods of ten nights and had 40,000 seconds on Geminga, 20,000s on PSR 0656 and about 10,000s on the Crab Pulsar, which was far more time than originally anticipated. The Geminga observations were capable of detecting pulsations as faint as 27 Magnitude in B. The UCG group used their own adaptive optics camera TRIFFID plus a MAMA detector supplied by the European Southern Observatory.

S. Russell (DIAS): (W/96A/94) *Abundances of Neutron-Capture Elements in Extremely Metal Poor Stars*, William Herschel Telescope, two bright nights. During the nights of 06 and 07 July, S. Russell used the Utrecht Echelle spectrograph on the WHT to observe high resolution spectra of very low metal abundance halo stars. The first night was clear, but was plagued by poor seeing. The second night, however, made up for this, being clear and with excellent seeing. The S/N target of 150 was only achieved in the brightest star, and then only for a small range of wavelengths. The bulk of the observations were in the vicinity of S/N = 100, which is an advance on previous work, but it remains to be seen whether the improvement is significant.

N. Smith et al. (Cork RTC): (J/96A/13) *Rapid Optical Variability in Radio-quiet Quasars with Extended Radio Features*, Jacobus Kapteyn Telescope, eight bright nights. CCD photometric observations were obtained of radio-quiet quasars with extended radio features in order to search for rapid optical variability in these objects. Weather conditions were very good with seven clear nights out of a total of eight. The reduction and analysis of the data is almost complete and will be published in Astronomy and Astrophysics. M. Rabbette (UCD) carried out the observations.

6 Seminars, Colloquia, Lectures

6.1 Statutory Public Lecture

D. Lemke (Max-Planck-Institut fuer Astronomie, Heidelberg) delivered the Annual Statutory Public Lecture for the School of Cosmic Physics. The lecture was entitled *Exploring the Cold Universe; First Results from Europe's Infrared Space Observatory* and took place at Trinity College Dublin, on 03 October.

6.2 Seminars, Open Lectures in the School

V. Icke (Leiden Observatory): *The Galaxy Distribution as a Voronoi Foam*, 26 January.

L. Nazarova (DIAS): *Excitation of Extended Gas in the Active Nuclei of NGC1068 and Mkn79*, 06 February.

R. Dendy (Culham Laboratory): *Fusion Research Achievements and Prospects* (a public lecture held at 10 Burlington Road), 07 February.

C.J. Davis (DIAS): *Outflows from Young Stars at near-IR Wavelengths*, 20 February.

G. Williger (MPIA, Heidelberg): *Large Scale Structure at* $z \sim 2.5$, 15 March.

A.J. Keane (DIAS): *Charge Abundances for Ultra-heavy Cosmic Ray Nuclei with* $Z > 74$, 02 April.

F. Walter (SUNY, Stony Brook, New York): *Low Mass Star Formation in OB Associations*, 23 April.

P. Kiraly (KFKI, Budapest): *The Heliosphere in the Interstellar Medium*, 14 May.

G.R. Keller (University of Texas at El Paso): *The US Deep Probe Experiment*, 30 May.

J. Webb (University of New South Wales and University of Sussex): *Using Quasars as Probes of the Early Universe*, 04 June.

C. Rola (IoA, Cambridge): *Analysis of the Nature of Emission-line Galaxies in Optical Redshift Surveys*, 17 June.

K. Farrell (DIAS): *An Explicit, Adaptive, Grid Algorithm for One-Dimensional Initial Value Problems*, 26 June.

O. Pols (IoA, Cambridge): *Supernova Progenitors from Close Binary Evolution*, 22 October.

Z. Zang (DIAS): *An X-ray study of three Sculptor Group galaxies*, 23 October (Internal talk, Astronomy).

D. Steel (University of Adelaide): *Project Spaceguard; Will Humankind go the way of the Dinosaurs?* (a public lecture held at 10 Burlington Road), 20 November.

6.3 Contributions to Scientific Meetings

G.F. Byrne: *P and S wave models for the upper mantle beneath the Kenyan Rift*, East African Rift Workshop, DIAS, Dublin, 09-11 October; *Upper Mantle pre- and post-rift Structures beneath Southern Kenya from Wide-angle Data: Regional Implications?*, AGU Meeting, San Francisco, 15-19 December.

C. Davis: *Kinematics and Excitation in the L1448 H_2 Jet*, The U.K. National Astronomy Meeting 1996, Liverpool, 08-12 April; *Understanding Molecular Outflows from Young Stars: RNO 15FIR*, The CCP7 Workshop on Astrophysical Spectroscopy at Submillimetre and Far-infrared wavelengths, Cantebury, England, 26-27 September.

L.O'C. Drury: Invited review, *Cosmic ray acceleration in SNRs*, at meeting "Interaction of Stars with their Environment", Visegrad, Hungary, 22-27 May; Invited review, *Cosmic Ray Astrophysics*, The 7th Asian Pacific Regional Meeting of the IAU, Pusan, S Korea, 16-23 August; *Dust Grains, SNR Shocks and the GCR Composition*, The 15th European Cosmic Ray Symposium, Perpignan, France, 27-30 August.

I. Elliott: *A Survey of Motivation in Science* (poster paper), IAU Colloquium 162 on "New Trends in Astronomy Teaching", University College London, 08-12 July.

K. Farrell: *An Explicit, Adaptive Grid Algorithm for One-Dimensional Initial-Value Problems*, ICMS meeting on "Grid Adaptation in Computational Partial Differential Equations", Edinburgh, Scotland, 01-05 July.

A.W.B. Jacob: *Northeast Atlantic Basins: Results from Wide-angle Seismic Profiles*, Irish Geological Association Research Meeting, UCD, Dublin, 23-25 February; *Travel-time Data obtained from the IGIDL (Lisbon) Seismic Bulletins*, EGS General Assembly, The Hague, Holland, 04-10 May.

A.J. Keane: *The Charge Spectrum of Ultra Heavy Nuclei, including Actinides, in the Cosmic Radiation*, The 31st COSPAR Scientific Assembly, Birmingham, England, 14-21 July; *Application and Anaylsis of SSNTD in the Investigation of Ultra Heavy Cosmic Rays in the Dublin-ESTEC Experiment*, The 18th International Conference on Nuclear Tracks in Solids, Cairo, Egypt, 01-05 September.

M. Landes: *Continental Crustal Structure and Topography*, AGU Meeting, San Francisco, 15-19 December.

F.E. Murphy: *Mapping D" and the CMB using High Resolution Seismic Reflection Data*, EGS General Assembly, The Hague, Holland, 04-10 May; *Mapping of Lower Mantle and CMB Structure Using PCP Data*, AGU Meeting, San Francisco, 15-19 December; *D" Topography: Fact or Fiction?* (via co-author), AGU Meeting, San Francisco, 15-19 December.

L. Nazarova: *Observations of ENLRs*, Astronomical Science Group of Ireland Spring Meeting, Dublin, 21 March.

O. Novak: *Seismic profile line F, western flank of the Kenya Rift*, East African Rift Workshop, DIAS, Dublin, 09-11 October.

B.M. O'Reilly: *The Evolution of the Hatton Continental Margin, North Atlantic*, EGS General Assembly, The Hague, Holland, 4-10 May; *Regional Gravity and Wide-Angle Seismic Studies: North-East Atlantic*, AGU Meeting, San Francisco, 15-19 December.

T.P. Ray: Invited review, *Jets from Young Stars*, at meeting "Interaction of Stars with their Environment", Visegrad, Hungary, 22-27 May; *The European Astrophysics Doctoral Network*, I.A.U. Colloquium 162 on "New Trends in Astronomy Teaching", University College London, 08-12 July; *Evidence for Disks Around Herbig Ae/Be Stars*, I.A.U. Colloquium 163 on "Accretion Phenomena and Related Outflows", Port Douglas, Queensland, Australia, 15-20 July; Invited talk, *Star Formation as seen by the Hubble Space Telescope*, National Portugese Astronomy and Astrophysics Meeting, University of Evora, Portugal, 17-20 September; Invited review, *Jets – A Star Formation Perspective*, Third Turin Workshop on "Jets from Active Galaxies and Stars", Turin, Italy, 08-15 December.

P.W. Readman: *New Gravity and Aero-magnetic Shaded Relief Maps of Britain and surrounding*

Continental Shelf: Tectonic Framework Revealed (via co-author), Geological Society Meeting, "Tectonics of the British Isles", Durham, 04 March 1995; *Tectonic Framework of the British/Irish Continental Shelf from new Gravity and Aeromagnetic Compilations* (via co-author), EAGE Conference, Glasgow, 29 May - 02 June 1995; *Gravity Variation in Ireland and Upper Crustal Tectonic Fabrics*, Irish Geological Association Research Meeting, UCD, Dublin, 23-25 February 1996; *The State of Isostasy in the Irish Crust and its Implications* (via co-author), Irish Geological Association Research Meeting, UCD, 23-25 February 1996; *An Overview of Crustal Structure in the Northwest TEST-ISZ Region from Gravity and Magnetic Data* (via co-author), EUROPROBE - Trans European Suture Zone (TESZ) Project, Wroclaw, Poland, April 1996; *Gravity Variation in Ireland and Upper Crustal Tectonic Fabrics*, EGS General Assembly, The Hague, Holland, 04-10 May 1996.

S.C. Russell: *ISO - Results at last*, Astronomical Science Group of Ireland Spring Meeting, Dublin (DIAS), 21 March; *ISOPHOT Observations of Bok Globules* (poster paper), ESA meeting on "The First Results from ISO", ESTEC, Holland, 29 May-02 June; *New Light on RV Tau Variables*, Conference on "Stellar Ecology", Isle of Elba, Italy, 23-29 June.

Z. Zang: *An X-ray Study of three Sculptor Group Galaxies*, Astronomical Science Group of Ireland Autumn Meeting, Armagh, 25 October.

6.4 External Seminars

C. Davis: *Understanding Bipolar Molecular Outflows from Young Stars*, John Moores University, Liverpool, 23 October.

L.O'C. Drury: *Molecular hydrogen spectra from C-shocks*, Centro de Astrofisica, University of Porto, Portugal, 17 January; *Interstellar dust and the Galactic Cosmic Rays*, University of Porto, Portugal, 16 October.

A.W.B. Jacob: *Seismic Refraction Methods*, ERASMUS Programme, Marine Geosciences Intensive Course, University College Galway, 03 September; *Transfrontier Data Exchange and its Importance*, Joint Research Centre Workshop, European Commission Joint Research Centre, ISPRA, Italy, 05 November.

E.J.A. Meurs: *Widespread Activity in the Centres of Galaxies*, SPCM, 15 February; *Source Selection Methods for Large Databases: the Extragalactic Content of the IRAS Catalog*, IAS, Frascati, Italy, 24 September; *Widespread Nuclear Activity in Galaxies*, Vienna Observatory, Austria, 14 October.

O. Novak: *Wide-angle Seismic Profiles in Kenya*, Polar Research Institute, Bremerhaven, Germany, 11 November.

B.M. O'Reilly: *Geological Interpretation of the RAPIDS profiles west of Ireland*, ERASMUS Programme, Marine Geosciences Intensive Course, University College Galway, 10 September.

T.P. Ray: *Star Formation*, University of Turin, Italy, 09 December; *Outflows from Young Stars*, University of Turin, Italy, 10 December.

J. Vermeulen, A.W.B. Jacob, R. Keary and P.M. Shannon: Seminars on the *GLORIA Project*, University College Galway, 26 February; Geological Survey of Ireland, Dublin, 01 March; University College Cork, 13 March; Fisheries Research Centre, Abbotstown, Dublin, 19 March.

6.5 Lecture Courses

L.O'C. Drury: High Energy Astrophysics lecture module for Eur M.Sc., University of Porto, Portugal, 10-19 January; M.Sc. lecture course, University of Porto, Portugal, 09-17 October; Lecture course on Topics in Astrophysics at the TCD Department of Mathematics during Michaelmas term.

E.J.A. Meurs: Lecture course of eighteen hours on "Stellar Dynamics" at TCD during Hilary and Trinity terms; Guidance provided for 4th year physics students from DCU and TCD.

L. Norci: Course of nine lectures on "Stellar Structure and Evolution" at TCD during Hilary term; Guidance for 4th year physics student from TCD.

T.P. Ray: Lecture course on Plasma Astrophysics to TCD Senior Sophisters (ie 4th year students) during Hilary term; Guidance provided for 4th year physics students from TCD.

S.C. Russell: Adult Education course of ten lectures at UCD entitled "Birth Life and Death in the Universe".

R. White: Tutorial course on "Observational Topics of Modern Astronomy" for TCD students taking the newly established astrophysics option in physics (Michaelmas term).

R. White, L.O'C. Drury, L. Norci and E.J.A. Meurs: Joint course of eight hours on "Topics in High-energy Astrophysics" at TCD (Department of Physics) during Michaelmas term.

6.6 Popular Lectures

I. Elliott: *Teaching Astronomy*, H.Dip.Ed. course, UCD, 06 February; *The Calendar, Time and the Millennium*, Astronomy Ireland, 26 February; *Astronomical Factors in Climate Change*, The Irish Meteorological Society, 20 April; *Irish Astronomers*, Science Week at North Dublin National School Project, Glasnevin, 09 May; *Astronomy On-Line*, CTC Conference, DCU, 27 August; *The Educational Potential of Astronomy*, Physics/Chemistry Course Committee, NCCA, Dublin Castle, 24 October.

K. Farrell: *Views of the Universe: Images and Movies from Voyager to the Hubble Space Telescope*, A presentation to transition year students at Lucan Community College, Co. Dublin, as part of the ESO/EAAE Astronomy On-Line Project, 27 September; *An Astronomy Observing Session with the Biggest Telescope in Ireland*, organised as part of the ESO/EAAE Astronomy On-Line Project, Lucan Community College, Co. Dublin, 06 November.

E.J.A. Meurs: *X-ray Activity in Galaxies*, Irish Astronomical Society, 04 March; *Activity in Galaxies*, TCD Astronomy and Space Society, 24 April; *Dunsink Science Expo*, RDS Conference on Science Centres for Ireland, Dublin, 20 June; *Active Nuclei of Galaxies*, Birr Whirlpool Star Party, 15 September.

T.P. Ray: *Newgrange*, Irish Astronomical Association, Belfast, 31 January; *The Search for Distant Planetary Systems*, Astronomy Ireland, Dublin, 14 October.

S.C. Russell: *ISO - The Infrared Space Observatory*, Astronomy Ireland, 11 March.

R. White: *Astronomy through Culture and through Time*, TCD Astronomy and Space Society, 13 November.

7 Expositions, Public Facilities and organisation of meetings

7.1 Dunsink Science Expo and Open Nights

The EXPO Committee continued with a number of meetings, mostly to refine aspects of the ceiling design and the computer game and to develop display panels. The ceiling model of the solar system was constructed and put in place in the exhibition room. An automated lighting sequence accompanied by a voice-over was installed to introduce visitors to the Expo. Work progressed on the design, construction and programming of the three play station computer quiz that will challenge the visitors. Six display panels were designed, in a process between EXPO Committee members and graphics designers, to provide an attractive coverage of astronomy from solar system, via stars, to the extragalactic universe. Only some refinements of the illustration material for these panels were left to be completed at the end of the year. The regular Open Nights were held as usual, with assistance from the Irish Astronomical Society.

7.2 The European Astrophysical Doctoral Network

The European Astrophysical Doctoral Network (EADN), under the chairmanship of T.P. Ray, continued to organise student astrophysics mobilities within the European Union, including one from Thessaloniki to DIAS (M. Tsiganis). In addition it held a Summer School on "Stellar Atmospheres: Theory and Observation" at Vrije University, Brussels, Belgium, during 10-19 September. Eight international experts in the field gave lecture courses on the school themes and experimental work was organised in co-operation with the Royal Observatory of Belgium. J.P. DeGreve acted as Scientific Director. In total 43 students attended the school and most were financially supported by the network through ERASMUS and Human Capital and Mobility funds.

7.3 East African Rift Workshop

A workshop for the KRISP (Kenya Rift International Seismic Project) was organised and held in DIAS during 10-12 October. Participants in this project (and a related project in Tanzania) attended from Germany (Karlsruhe and Potsdam), U.K. (Leicester), Denmark (Copenhagen), U.S.A. (Menlo Park, El Paso and Pennsylvania) and DIAS. Latest results from the KRISP 94 experiments were presented and discussed. The discussions proved very fruitful, considerable benefit being gained by having specialists from the different disciplines involved in the project present together. The first results from a Pennsylvania

State University broadband instrument array in Tanzania were also presented. This experiment had been very successful and the results most interesting and relevant to KRISP. The workshop continued with a discussion of possible future experiments in East Africa and an outline proposal to the EU was formulated.

8 External Work

8.1 Geophysics Section

T.A. Blake: COMBO deployment in Portugal, 19-31 July; European Seismological Commission, Reykjavik, Iceland, 07-14 September; Transfrontier project meeting, University of Strasbourg, France, 17-20 October.

G.F. Byrne: American Geophysical Union Meeting, San Francisco, 13-21 December.

F. Hauser: EGS General Assembly, The Hague, Holland, 04-11 May; COMBO deployment, Portugal, 19-31 July; RAPIDS visit to University of Hamburg and GFZ, Potsdam, Germany, 24 November - 03 December.

C.M. Horan: COMBO deployment in Portugal, 16 July - 04 August.

A.W.B. Jacob: Visit to BGS and Edinburgh University, 13-14 February; EGS General Assembly, The Hague, Holland, 04-10 May; AIRS project visit to Southampton Oceanography Centre, 20 May; COMBO visits to Lisbon, Portugal, 29 June - 03 July; 20-23 July; 05-06 August; European Seismological Commission, Reykjavik, Iceland, 07-14 September; Transfrontier Project meeting, University of Strasbourg, 17-19 September; IGCP400 planning meeting, Brussels and Workshop at JRC, Ispra, Italy, 03-05 November; COMBO, Madrid, 11-12 November; COMBO, Leeds, 18-19 November; RAPIDS visit to University of Hamburg, 23-25 November; AIRS, Southampton Oceanography Centre, 27-28 November; US Geological Survey and American Geophysical Union Meeting, San Francisco, 11-21 December.

M. Landes: VARNET visit to Potsdam, Germany (with ten days at the University of Copenhagen and seven days at the University of Karlsruhe), 19 June - 01 September; US Geological Survey, Menlo Park, California, 06-21 December.

K. McGrane: AIRS Project, at sea in M.V. SIREN, 10 August - 05 September; Southampton Oceanography Centre, 05 October - 17 December.

D. Meghen: COMBO deployment in Portugal, 16-22 July.

F.E. Murphy: EGS General Assembly and COMBO meeting, The Hague, Holland, 04-11 May; COMBO deployment, Portugal, 11-23 July; COMBO visits to Leeds, 09-12 September; 12-19 November.

O. Novak: KRISP visits to the University of Karlsruhe, Germany, 05 April - 15 May; 11 October - 17 November.

B.M. O'Reilly: Gravity fieldwork, 26 March -06 April; EGS General Assembly, The Hague, Holland, 04-10 May; VARNET, 02-19 June; AIRS project, at sea in M.V. SIREN, 10 August - 05 September; Gravity fieldwork, 30 October - 12 November; RAPIDS visit to University of Hamburg, 24 November - 02 December; American Geophysical Union Meeting, San Francisco, 13-21 December.

P.W. Readman: University of Aarhus, Denmark, 25 January - 04 February; Gravity fieldwork, 26 March -06 April; EGS General Assembly, The Hague, Holland, 04-10 May; VARNET, 02-19 June; AIRS project, at sea in M.V. SIREN, 10 August - 05 September; Gravity fieldwork, 30 October - 12 November; Southampton Oceanography Centre, 25-28 November; American Geophysical Union Meeting, San Francisco, 13-21 December.

G. Wallace: COMBO visit to Portugal, 29 June - 03 July; COMBO deployment in Portugal, 11 July - 04 August.

8.2 Astronomy Section

W. Dumpleton: Conference on Science Centres for Ireland, RDS, Dublin, 19-20 June.
I. Elliott: IAU Colloquium 162 on "New Trends in Astronomy Teaching", University College London, 08-12 July; Astronomical Science Group of Ireland Autumn Meeting, Armagh, 25 October.

B. Jordan: Meeting for OMC CCD final specifications and testing, EEV, Chelmsford, England, 17 January; Fifth OMC consortium meeting, INTA, Madrid, 30 January; Flight Model and Qualification Model OMC CCD meeting, MSSL, England, 28 March; Flight Model OMC CCD meeting, ESTEC, Noordwijk,

Holland, 29 March; Sixth OMC consortium meeting, INTA, Madrid, 18 June; Seventh OMC consortium meeting, CSL, Liege, Belgium, 23 July; OMC Engineering Model meeting, MSSL, England, 14 November; Meeting of INTEGRAL engineering groups, ESTEC, Noordwijk, Holland, 19 November; Eighth OMC consortium meeting, INTA, Madrid, 03 December.

E.J.A. Meurs: TMR Physics Panel, Brussels, 28 February - 01 March; Astronomical Science Group of Ireland Spring Meeting, 21 March, Dublin; Conference on Science Centres for Ireland, RDS, Dublin, 19-20 June; TMR Physics Panel, Brussels, 20-23 August.

L. Nazarova: Astronomical Science Group of Ireland Spring Meeting, Dublin, 21 March.

L. Norci: Astronomical Science Group of Ireland Spring Meeting, Dublin, 21 March; Conference on Science Centres for Ireland, RDS, Dublin, 19-20 June.

R. White: Editorial meeting, Vistas in Astronomy, London, 24 September; Editorial meeting, Vistas in Astronomy, London, 27 November.

Z. Zang: Astronomical Science Group of Ireland Spring Meeting, Dublin, 21 March; IAU Colloquium 159, Shanghai, China, 17-20 June; Astronomical Science Group of Ireland Autumn Meeting, Armagh, 25 October.

8.3 Astrophysics Section

M. Corcoran: Workshop on star formation, Service d'Astrophysique, Centre d'Études de Saclay, Paris, 07-11 September.

C.J. Davis: The U.K. National Astronomy Meeting 1996, Liverpool, 08-12 April; The CCP7 Workshop on Astrophysical Spectroscopy at Submillimetre and Far-infrared wavelengths, Cantebury, England, 26-27 September; Astronomical Science Group of Ireland Autumn Meeting, Armagh, 25 October.

J. Donnelly: IRMA detector retrieval from Concorde aircraft, London, 30-31 January; IRMA Contractors Meeting, Brussels, 4-5 March; IRMA Contractors Meeting, Killiney, 24-25 October.

L.O'C. Drury: MSc lecture course, University of Porto, Portugal, 10-19 January; Management committee meeting, Armagh Observatory, 25 January; Nominations committee meeting, Armagh Planetarium, 01 March; HCM network workshop, Beauly, Scotland, 04-08 March; Isophot consortium meeting, MPA, Heidelberg, Germany, 20-22 March; Hungarian Astronomical Society meeting, "Interaction of Stars with their Environment", Visegrad, Hungary, 22-27 May; TMR proposal preparation, Oxford, England, 12-14 June; workshop "Next generation X-Ray observatories", Leicester, England, 10-13 July; The 31st COSPAR Scientific Assembly, Birmingham, England, 14-18 July; The 7th Asian Pacific regional meeting of the IAU, Pusan, S Korea, 16-23 August; The 15th European Cosmic Ray Symposium, Perpignan, France, 27-30 August; workshop on 3D modulation of cosmic rays, ISSI Berne, Switzerland, 17-20 September; HCM network meeting, CEA Cadarache, France, 24-27 September; MSc lecture course, University of Porto, Portugal, 09-17 October; visit to Centro da Fusao Nuclear, IST, Lisboa, Portugal, 17-19 October; ASGI Autumn Meeting, Armagh, 25 October; Discussions with R.O. Dendy, Culham, England, 06-07 November; HCM network meeting, Ramsau, Germany, 02-05 December; proposal and paper writing, MPK Heidelberg, Germany, 05-15 December.

E. Flood: IRMA Contractors Meeting, Brussels, 4-5 March; IRMA Contractors Meeting, Killiney, 24-25 October.

A.J. Keane: Experimental work at Brookhaven National Laboratory, Upton, New York, USA, 01-26 January; Institute of Physics meeting, Kilkenny, 29-31 March; The 31st COSPAR (Committee on Space Research) Scientific Assembly, Birmingham, England, 14-20 July; The 18th International Conference on Nuclear Tracks in Solids, Cairo, Egypt, 01-05 September.

R. Keegan: IRMA Contractors Meeting, Killiney, 24-25 October.

D. O'Sullivan: Arrangements for installation of new IRMA detectors on Concorde aircraft and presentation of latest DIAS results, London, 19-20 September; IRMA Contractors Meeting, Killiney, 24-25 October.

S. O'Sullivan: Energetic Particles in Astrophysical and Space Plasmas Network Workshop, Cadarache, France, 24-27 September.

T.P. Ray: Collaborative visit in connection with a joint Hubble Space Telescope programme, MPA, Heidelberg, 15-26 January; Hungarian Astronomical Society meeting, "Interaction of Stars with their Environment", Visegrad,

Hungary, 22-27 May; First ISO (Infrared Space Observatory) Workshop, ESTEC, Nordwijk, Holland, 29 May - 02 June; Arrangements for EADN (European Astrophysical Doctoral Network) summer school, Vrije University, Brussels, 25 June; Reduction of radio interferometer data, Jodrell Bank, University of Manchester, 27 June-03 July; I.A.U. Colloquium 162, "New Trends in Astronomy Teaching", University College London, 08 July; I.A.U. Colloquium 163, "Accretion Phenomena and Related Outflows", Port Douglas, Queensland, Australia, 15-20 July; National Portuguese Astronomy and Astrophysics Meeting, University of Evora, 17-20 September; Reduction of ISOPHOT data, MPA, Heidelberg, 07-11 October; Astronomical Science Group of Ireland Autumn Meeting, Armagh, 25 October; ISO (Infrared Space Observatory) Time Allocation Committee meeting, ESTEC, Nordwijk, Holland, 10-12 November; Third Turin Workshop on "Jets from Active Galaxies and Stars", Turin, Italy, 08-15 December.

S.C. Russell: Presided at an Open Night for the public at Dunsink Observatory, Dublin, 27 March; ESA meeting on "The First Results from ISO", ESTEC, Holland, 29 May-02 June; Meeting on "Stellar Ecology", Isle of Elba, Italy, 23-29 June; Observing mission, William Herschel Telescope (WHT), La Palma, 05-09 July; Appointed Senior Visitor at the European Southern Observatory, Santiago, Chile, 16 September-15 December.

D. Zhou: IRMA Contractors Meeting, Killiney, 24-25 October.

9 Miscellanea

L.O'C. Drury was elected Vice-Chairman of the Commission on Cosmic Rays of the International Union of Pure and Applied Physics.
A.W.B. Jacob was awarded the Gold Badge of the European Geophysical Society at its General Assembly in The Hague in May.

A.W.B. Jacob was co-Convener with R. Kind and M. Weber (Germany) of the Symposium on "Global Seismology and Large Scale Dynamics" at the 21st General Assembly of the European Geophysical Society in the Hague in May and was Chairman for one of the sessions. He was also co-Convener with L. Vinnik (Russia) of the Symposium on "Deep Structure of Eurasia from the Lower Crust to the Core-Mantle Boundary" at the XXV General Assembly of the European Seismological Commission, Reykjavik, Iceland in September and again was Chairman for one of the sessions.

A.W.B. Jacob completed his term (1992-1996) as General Secretary and Member of Council of the European Geophysical Society in May.

L.O'C. Drury completed his term as Chairman of the National Committee for Physics (1992-1996) and was appointed as the DIAS representative on the Committee for the next term of office (1996-2000).

T.P. Ray was appointed as a DIAS representative on the National Committee for Astronomy and Space Research (a newly constituted National Committee derived from a merger of the Royal Irish Academy Space Research Committee with the former National Committee for Astronomy). He also continued as President of the Astronomical Science Group of Ireland, as Secretary of the La Palma Advisory Committee, as Chairman of the European Astrophysical Doctoral Network and as a member of the Infrared Space Observatory Time Allocation Committee.

R. Keegan successfully defended his PhD thesis during the year. The external examiner was L. Tommasino (ANPA, Rome).

C.J. Davis, formerly of the the Royal Observatory, Edinburgh and the Max Planck Institute for Astronomy, Heidelberg, joined the Star Formation Group in January as a postdoctoral research assistant (PDRA) with joint funding from Forbairt and DIAS.

M. Tsiganis (University of Thessaloniki) worked in the Star Formation Group as a visiting student, under the EU ERASMUS scheme, from February to June.

M. Wilkinson completed and successfully defended his MSc thesis work during the year.

L.O'C. Drury and E.J.A. Meurs collaborated to provide prospective physics students with study information at TCD on 16 November.

E.J.A. Meurs became Honorary President of the newly established TCD Astronomy and Space Society. He was also appointed to the National Committee for Astronomy and Space Research of the Royal Irish Academy, as an Academy nominee. Further he served, as before, as Physics Panel member for the selection of EU TMR Fellowships.

On 20 April a group from the Irish Astronomical Association (based in Belfast) visited Dunsink.

I. Elliott continued as a Council member of the Royal Dublin Society and as a member of its Science Committee. He chaired the Steering Group for the RDS Conference on "Science Centres for Ireland", 19-21 June. The conference delegates paid an evening visit to Dunsink Observatory on 20 June.

As part of the European Week for Scientific and Technological Culture, a National Steering Committee chaired by I. Elliott and G. Moloney (North Dublin National School Project) met regularly to promote "Astronomy On-Line", an initiative of the European Southern Observatory and the European Association for Astronomical Education with support from the European Union. The aim of the programme was to introduce schools to the potential of modern communications technology and to the latest discoveries in astronomy. All secondary schools were notified and a homepage was set up on the Dunsink computer, thanks to Webmaster C. Power (TCD). Despite some technical difficulties, there was participation from 120 individuals drawn from fifteen schools and five amateur groups.

Apart from routine solar information for architects and film companies, Dunsink Observatory supplied twenty-five certified statements of Lighting-up Times for legal purposes, prepared by I. Elliott.

10 Publications

10.1 Journals and other Refereed Publications

C.J. Davis, J. Eislöffel and M.D. Smith: *Near-IR and Optical Observations of an Obliquely Viewed Bow Shock -- AS 353A/HH 32*, Astrophys. J., Vol 463, pp 246-253 (1996).

C.J. Davis and M.D. Smith: *Near-IR Imaging and Spectroscopy of DR21: a Case for Supersonic Turbulence*, Astron. Astrophys., Vol 310, pp 961-969 (1996).

C.J. Davis and M.D. Smith: *Echelle Spectroscopy of Shocked H_2 in the L1448 Outflow*, Astron. Astrophys., Vol 309, pp 929-938(1996).

C.J. Davis and T.P. Ray with J. Eislöffel and M.D. Smith: *Molecular Hydrogen in the Outflow from Cep E*, Astron. J., Vol 112, pp 2086-2093 (1996).

T.P. Downes: *Numerical Simulations of H_2 Emission in Jets from Young Stellar Objects*, Astrophys. Lett. and Comm. Vol 34, pp 309-314 (1996).

L.O'C. Drury: *Shell Type Supernova Remnants*, Space Science Reviews, Vol 75, pp 269-277 (1996).

L.O'C. Drury: *Free-fall Timescale in an Arbitrary Number of Spatial Dimensions*, QJRAS, Vol 37, pp 255-256 (1996).

L.O'C. Drury and P. Duffy with K.G. McClements and R.O. Dendy: *Excitation of ion cyclotron harmonic waves in cosmic ray shock precursors*, Mon. Not. R. Astr. Soc., Vol 280, pp 219-226 (1996).

L.O'C. Drury, P. Duffy and J.G. Kirk: *Limits on diffusive shock acceleration in dense and incompletely ionized media*, Astron. Astrophys., Vol 309, pp 1002-1010 (1996).

L.O'C. Drury and S. Russell with D. Lemke et al (48 co-authors): *ISOPHOT - Capabilities and Performance*, Astron. Astrophys., Vol 315, pp L64-L70 (1996).

R. Hes, P.D. Barthel and R.A.E. Fosbury: *Emission Line Imaging of 3CR Quasars and Radio Galaxies*, Astron. Astrophys.,Vol 313, pp 423-438 (1996).

I. O'Brien and L.O'C. Drury: *Non-LTE Excitation of H_2 in Magnetized Molecular Shocks*, Mon. Not. R. Astr. Soc., Vol 280, pp 550-554 (1996).

B.M. O'Reilly, F. Hauser, A.W.B. Jacob and P.M. Shannon: *The Lithosphere below the Rockall Trough: Wide-angle Seismic Evidence for Extensive Serpentinisation*, Tectonophysics, Vol 255, pp 01-23 (1996).

B.M. O'Reilly, F. Hauser, A.W.B. Jacob, P.M.Shannon, J. Makris and U. Vogt: *Wide-angle Seismics: A Key to Understanding the Geological Development of the North Atlantic*, Irish Marine Science 1995 (eds. B.F. Keegan and R. O'Connor), Galway University Press, Galway, pp 475-484 (1996).

B.M. O'Reilly, P.W. Readman and T. Murphy: *The Gravity Signature of Caledonian and Variscan Tectonics in Ireland*, Phys. Chem. Earth, Vol. 21, pp 299-304 (1996).

D. O'Sullivan, A. Thompson, A.J. Keane, L.O'C. Drury and K.-P. Wenzel: *Investigation of $Z \geq 70$ Cosmic Ray Nuclei on the LDEF Mission*, Radiation Measurements, Vol. 26, pp 889-892 (1996).

D. O'Sullivan and J. Byrne with L. Tommasino, F. Caggiati, M. Cavaioli, M. Notaro, R. Teidori, G. Torri, D. Zhou: *Passive Multidetector Stack for the assessment of Aircrew Exposure*, Environmental International, Vol 22, pp 115-119 (1996).

V.F. Polcaro, C. Rossi, L. Viotti and L. Norci: *Similarities and Differences between the [WC2] Nucleus of NGC 5189 and the WO Star Sand 4*, Astrophys. Space Sci., Vol 238, pp 59-62 (1996).

T.P. Ray, R. Mundt, J. Dyson, S.A.E.G. Falle and A. Raga: *HST Observations of Jets from Young Stars*, Astrophys. J. (Letters), Vol 468, pp L103-L106 (1996).

S.C. Russell: *The Lithium Abundance Dispersion in the Pleiades?*, Astrophys. J., Vol 463, pp 593-601 (1996).

10.2 Conference Proceedings

T.A. Blake and A.W.B. Jacob with R. Sleeman, A.B. Walker and the Transfrontier Group: *Rapid Transfrontier Seismic Data Exchange Network*, European Seismological Commission, XXV General Assembly, p 143 (1996).

G.F. Byrne, A.W.B. Jacob and O. Novak: *Upper Mantle pre- and post-rift Structures beneath southern Kenya from Wide-angle Data: Regional Implications?*, Eos, Vol 77, p F704 (1996).

M. Corcoran and T.P. Ray: *Forbidden Line Emission and Correlations with Infrared Excess in Herbig Ae/Be Stars*, Disks and Outflows Around Young Stars, Proceedings of the Heidelberg Conference in Honour of H. Elsässer (eds. S.V.W. Beckwith, A. Natta and J. Staude), Lecture Notes in Physics Series, Springer-Verlag, pp 276-280 (1996).

C.J. Davis: *Understanding Molecular Outflows from Young Stars*, Proceedings of the CCP7 Workshop on Astrophysical Spectroscopy at Submillimetre and Far-Infrared Wavelengths (ed. C.S. Jeffery), CCP7 Newsletter number 24, pp 21-22 (1996).

K. Farrell: *Explicit and Adaptive Grid Methods for Implicit Conservative Gas Dynamics in 1-Dimension*, The Irish Astronomical Journal, Vol 23, pp 165-170 (1996).

A.W.B. Jacob with N.A. Dias et al.: *Travel-time data obtained from the IGIDL (Lisbon) Seismic Bulletins*, Annales Geophysicae, Vol 14, p C42 (1996).

A.W.B. Jacob and G.F. Byrne with J.R. Ritter and the KRISP Working Group: *Imaging the Deep Structure of Quaternary Volcanoes: II Chyulu Hills Volcanic Field, SE Kenya*, European Seismological Commission, XXV General Assembly, p 98 (1996).

A.J. Keane, D. O'Sullivan, A. Thompson, L.O'C Drury, K.-P. Wenzel: *The Charge Spectrum of Relativistic Ultra Heavy Cosmic Ray Nuclei; further results from the Dublin-ESTEC experiment on LDEF*, The 31st Scientific Assembly of COSPAR (Birmingham, England), E1.7-0002 (1996).

M. Landes with W. Mooney: *Continental Crustal Structure and Topography*, Eos, Vol 77, p F488 (1996).

E. J. A. Meurs and L. Norci: *On the Nature of High L_X IRAS Galaxies*, in "Röntgenstrahlung from the Universe" (eds. Zimmermann et al), MPE Report 263, pp 481-482 (1996).

E.J.A. Meurs: *A Nuclear Luminosity Function for Seyferts*, IAU Symp. 175, pp 541-542 (1996).

E.J.A. Meurs: *Possible Evidence for a Binary Massive Black Hole in the Galactic Nucleus*, IAU Symp. 169 (eds. L. Blitz and P. Teuben), pp 285-286 (1996).

F.E. Murphy, A.W.B. Jacob, J. Neuberg and COMBO Group: *Mapping of Lower Mantle and CMB Structure Using PCP Data*, Eos, Vol 77, p F680 (1996).

F.E. Murphy with A. O'Mongain and J. Neuberg: *Mapping D" and the CMB using High Resolution Seismic Reflection Data*, Annales Geophysicae, Vol 14, p C39 (1996).

L. Norci, H. Ebeling, H. Boehringer, W. Voges and R. Treumann: *ROSAT Survey: the Einstein EMSS Galaxy Clusters Revisited*, in "Röntgenstrahlung from the Universe" (eds. Zimmermann et al), MPE Report 263, pp 603-604 (1996).

L. Norci, L. Feretti and E.J.A. Meurs: *Abell 2241: Clusters with Head-tails at X-rays*, IAU Symp. 175, pp 361-362 (1996).

O. Novak, A.W.B. Jacob, J.R.R. Ritter and C. Prodehl: *Deep Structure of the Chyulu Hills, SE Kenya: results of KRISP*, Annales Geophysicae, Vol 14, p C54 (1996).

A. O'Mongain, J. Neuberg, F.E. Murphy, A.W.B. Jacob et al: *D" Topography:Fact or Fiction?*, Eos, Vol 77, p F679 (1996).

B.M. O'Reilly, F. Hauser, P.W. Readman and U. Vogt: *The evolution of the Hatton Continental Margin, North Atlantic*, Annales Geophysicae, Vol 14, p C192 (1996).

B.M. O'Reilly, P.W. Readman and F. Hauser: *Regional Gravity and Wide-Angle Seismic Studies: North-East Atlantic*, Eos, Vol 77, p F703 (1996).

V.F. Polcaro, L. Norci, C. Rossi and R. Viotti: *Do we Really Need the WO Spectral Type?*, Proc. 33rd Liege International Astrophysical Colloquium, "Wolf-Rayet Stars in the Framework of Stellar Evolution" (eds. J.M. Vreux et al), pp 23-30 (1996).

P.W. Readman, B.M. O'Reilly, and T. Murphy: *Gravity Variation in Ireland and Upper Crustal Tectonic Fabrics*, Annales Geophysicae, Vol 14, p C72 (1996).

T.P. Ray: *Jets from Young Stars*, invited review in the NATO ASI on Solar and Astrophysical MHD Flows, Heraklion, Crete (ed. K. Tsinganos), Kluwer Academic Publishers, pp 539-566 (1996).

A. Thompson and D. O'Sullivan with F. Jansen, T. Röwf and K.-P. Wenzel: *Ultra Heavy Cosmic Rays — the experiment on the LDEF satellite and the Halo Diffusion Model*, The 31st COSPAR Scientific Assembly (Birmingham, England), E1.7-0011 (1996).

10.3 Books, Theses, Reports and Sundry Publications

I Elliott: *The Exotic World of Massive Black Holes*, Technology Ireland, March, pp 17-20 (1996).

I.Elliott: *Science Centres for Ireland*, The Irish Scientist, Nr. 4, p 11 (1996).

I.Elliott: *Astronomy On-Line*, CTC Link '96 Conference, European Linkages in Teaching Computing at Primary and Secondary Level, DCU, 26-30 August, pp 50-52 (1996).

I. Elliott: Regular monthly articles on *Astronomy* in Parent and Teacher, 1996.

A.W.B. Jacob with R. Kind and M. Weber: *Global Seismology and Large Scale Dynamics*, EGS Newsletter, Nbr. 59, pp 10-11 (1996).

A.W.B. Jacob: *Recorded material from Irish Sea earthquake of 19 July 1984*, for Children's Discovery Museum, San Jose, California (1996).

A.W.B. Jacob: *Recording of earthquake centred off coast of Wales (O.35) 1984*, recording on CD "Pulse of the Planet: Extraordinary Sounds from the Natural World", CD by Jim Metzner, The Nature Co. (1994).

A.W.B. Jacob, J. Vermeulen, R. Keary and P.M. Shannon: *Reconnaissance Survey of the Irish (European) Atlantic Shelf/Shelf Edge using GLORIA, Phase 1: Project Definition*, Report to the Marine Institute (1996).

R. Keegan: *Let Spectrum Generation and Proton Induced Secondary Contribution to Total Dose Measured in Low Earth Orbit*, PhD Thesis, University College, Dublin, National University of Ireland (1996).

P. Morris with J. Verhoef et al: *Magnetic Anomalies of the Arctic and North Atlantic Oceans and Adjacent Land Areas*, Geological Survey of Canada, Open Files 3125,3280,3281 and 3282 (1996).

M. Wilkinson: *Using Voronoi Techniques to determine the Shapes of Photon Sources*, M.Sc. Thesis, Trinity College, Dublin University (1996).

INSTITIÚID ARD-LÉINN BHAILE ÁTHA CLIATH
(Dublin Institute for Advanced Studies)

Financial Statements for year ended 31 December 1996

CONTENTS

INSTITIÚID ARD-LÉINN BHAILE ÁTHA CLIATH
(Dublin Institute for Advanced Studies)

Statement of Responsibilities of the Council

The Council of the Dublin Institute for Advanced Studies is required under section 28(2) of the Institute for Advanced Studies Act 1940 to prepare financial statements in such form as shall be approved by the Minister with the concurrence of the Minister for Finance. In preparing those financial statements the Council is required to:

- select suitable accounting policies and apply them consistently;
- make judgements and estimates that are reasonable and prudent;
- prepare the financial statements on the going concern basis unless it is inappropriate to presume that the Institute will continue in operation.

The Council is responsible for keeping proper books of account which disclose with reasonable accuracy at any time the financial position of the Institute and which enable it to ensure that the financial statements comply with Section 28(2) of the Act. The Council is also responsible for safeguarding the assets of the Institute and for taking reasonable steps for the prevention and detection of fraud and other irregularities.

Chairman

Council Member

INSTITIÚID ARD-LÉINN BHAILE ÁTHA CLIATH
(Dublin Institute for Advanced Studies)

Financial Statements for year ended 31 December 1996

GENERAL

The Institute was established under the Institute for Advanced Studies Act, 1940.
Its functions include the provision of facilities for the furtherance of advanced studies and the conduct of research in specialised branches of knowledge.
It comprises three Schools - Celtic Studies, Theoretical Physics and Cosmic Physics.

ACCOUNTING POLICIES

1. Accounting basis

The financial statements have been prepared under the historical cost convention.

2. Oireachtas Grants

Income is shown on a cash receivable basis.

3. Fixed Assets

Fixed Assets comprise the furniture, equipment, computers and motor vehicles of the Institute and are shown at cost less accumulated depreciation. The rates of depreciation, calculated on a straight line basis, are as follows :-

Furniture and Equipment	10%
Computers	25%
Motor Vehicles	25%

Premises occupied by the Institute are leased from the Office of Public Works.

4. Capital Reserve

The capital reserve comprises income allocated for the purchase of fixed assets. It is written down in line with the depreciation of the related assets.

5. Library

Expenditure on library books and materials is charged to the Income and Expenditure Account. The value of such books and materials is estimated at £995,498, based on a 1994 valuation.

6. Publications

Expenditure on publications is written off in the year in which it is incurred. The estimated value of such publications on hand at 31 December 1996 was £797,020.

7. Superannuation

All superannuation benefits to or in respect of employees of the Institute under its superannuation schemes are met out of grants in the year of payment. Contributions in respect of these schemes are netted against salaries charged in the Account. No provision is made in these financial statements for future benefits.

INSTITIÚID ARD-LÉINN BHAILE ÁTHA CLIATH
(Dublin Institute for Advanced Studies)

Financial Statements for year ended 31 December 1996

Income and Expenditure Account

	Notes	1996 £	1995 £
Income			
Oireachtas Grant		2,880,000	2,840,000
Sales of Publications		35,722	33,242
Celtic Studies Fees		1,125	8,421
School of Theoretical Physics	2	192,163	29,067
School of Cosmic Physics	2	527,605	225,746
Miscellaneous	8	25,737	29,600
		3,662,352	3,166,076
Transfer (to)/from Capital Reserve	4	(97,768)	(279,134)
		3,564,584	2,886,942
Expenditure			
School of Celtic Studies		639,366	654,530
School of Theoretical Physics		481,830	415,170
School of Cosmic Physics		1,615,834	1,345,125
Administration		840,154	854,317
		3,577,184	3,269,142
Surplus (Deficit) for year		**(12,600)**	**(382,200)**
Balance at 1 January		143,210	525,410
Balance at 31 December		**130,610**	**143,210**

The Statement of Accounting Policies and notes 1 to 9 form part of these financial statements.

Deirdre Donnelly
CHAIRMAN - COUNCIL OF THE INSTITUTE

REGISTRAR

INSTITIÚID ARD-LÉINN BHAILE ÁTHA CLIATH
(Dublin Institute for Advanced Studies)

Financial Statements for year ended 31 December 1996

Balance Sheet as at 31 December 1996

	Notes	1996 £	1995 £
Assets			
Fixed Assets	3	633,743	535,975
Current Assets:			
Cash on Hands and at Bank		387,378	473,729
Debtors and Prepayments		111,510	29,460
Total Assets		**1,132,631**	**1,039,164**
Less Liabilities			
Creditors - Amounts falling due within one year			
Creditors and Accruals		248,348	187,152
Research Programmes and Fees	2	79,249	129,075
Lease obligations	7	4,614	4,614
Creditors - Amounts falling due after one year			
Funds	5	35,490	33,947
Lease obligations	7	577	5,191
Total Liabilities		**368,278**	**359,979**
Net Assets		**764,353**	**679,185**
Financed by:			
Surplus Income and Expenditure Account		130,610	143,210
Capital Reserve	4	633,743	535,975
		764,353	**679,185**

The Statement of Accounting Policies and notes 1 to 9 form part of these financial statements.

CHAIRMAN - COUNCIL OF THE INSTITUTE

REGISTRAR

INSTITIÚID ARD-LÉINN BHAILE ÁTHA CLIATH
(Dublin Institute for Advanced Studies)

Financial Statements for year ended 31 December 1996.

Cash Flow Statement

	Notes	1996 £	1995 £
Operating Activities			
Surplus (Deficit) per Income & Expenditure		(12,600)	(382,200)
Adjustment for Non-Operating Items			
Interest		(24,693)	(20,299)
Profit/Loss on Disposal		2,032	589
Movement on Capital Account		97,768	279,134
Adjustment for Non-Cash Items			
Depreciation		155,556	107,662
Decrease/(increase) in debtors		(82,050)	2,667
Increase/(decrease) in creditors/funds		58,125	64,882
Increase/(decrease) in research programmes and fees		(49,826)	68,706
Net Cash Flow from Operating Activities		**144,312**	**121,141**
Returns on Investments and Servicing of Finance			
Interest		24,693	20,299
Investing Activities			
Purchase of Fixed Assets	3	(255,356)	(387,385)
Net Cash Inflow(Outflow)		**(86,351)**	**(245,945)**
Analysis of Movement in Cash and Cash Equivalents			
Balance at 1 January		473,729	719,674
Net Cash Flow		(86,351)	(245,945)
Balance at 31 December		**387,378**	**473,729**

The Statement of Accounting Policies and notes 1 to 9 form part of these financial statements.

CHAIRMAN - COUNCIL OF THE INSTITUTE

REGISTRAR

INSTITIÚID ARD-LÉINN BHAILE ÁTHA CLIATH
(Dublin Institute for Advanced Studies)

Notes to the Financial Statements

1 Detailed Analysis of Income & Expenditure for the year ended 31/12/1996

INCOME	Notes	School of Celtic Studies	School of Theoretical Physics	School of Cosmic Physics	Adminis-tration	1996 Total	1995 Total
		£	£	£	£	£	£
Oireachtas Grants		650,196	354,374	1,155,820	719,610	2,880,000	2,840,000
Sales of Publications		35,674	15	33		35,722	33,242
School of Celtic Studies		1,125				1,125	8,421
School of Theoretical Physics	2		192,163			192,163	29,067
School of Cosmic Physics	2			527,605		527,605	225,746
Miscellaneous	8				25,737	25,737	29,600
		686,995	546,552	1,683,458	745,347	3,662,352	3,166,076
Transfer (to)/from Capital Reserve	4	(19,588)	(62,603)	(131,247)	115,670	(97,768)	(279,134)
		667,407	483,949	1,552,211	861,017	3,564,584	2,886,942
EXPENDITURE							
Salaries, Wages and Superannuation	9	527,168	212,207	878,665	348,102	1,966,142	1,926,477
Scholarships		37,121	46,597	44,662		128,380	142,261
Honoraria		907	100	628		1,635	5,275
Library (incl. Microfilms)		27,078	54,437	42,619		124,134	117,198
Publications		13,017		49	1,994	15,060	22,553
General Administration	6				261,487	261,487	297,769
Travel and Survey Expenses		5,068	14,582	46,432	6,380	72,462	75,817
Symposia & Seminar Expenses		2,815	492			3,307	3,209
Consumable & Maintenance				25,956		25,956	31,666
Special Commitments and Projects		1,350	126,056	547,118		674,524	301,572
General Expenses		24,842	23,995	29,705	56,452	134,994	181,126
Visiting Committee							7,245
Book Storage					7,899	7,899	7,522
Dunsink Renovation					252	252	37,833
Loss on Disposals					2,032	2,032	589
Depreciation	3				155,556	155,556	107,662
Leasing charges			3,364			3,364	3,368
		639,366	481,830	1,615,834	840,154	3,577,184	3,269,142
SURPLUS (DEFICIT) FOR YEAR		28,041	2,119	(63,623)	20,863	(12,600)	(382,200)
Balance at 1 January		50,001	(28,940)	12,366	109,783	143,210	525,410
Balance at 31 December		78,042	(26,821)	(51,257)	130,646	130,610	143,210

Notes to the Financial Statements

2 **Research Programmes and Fees**

School of Cosmic Physics

Project	Contributor	Opening Balance	Receipts	Applied as Income	Unexpended/ Overexpended	Total
		£	£	£	£	£
Geotwin	GB fees		9,000	9,000		
HOGS	BGS		2,596	2,596		
Isophot	ESA	50	24,685	28,086	(3,351)	
Rapids	Forbairt	771		24	747	
La Palma	Forbairt		5,000	5,000		
EADN - Erasmus/HCM	EU	9,312	36,880	20,240	25,952	
Low Mass Star	Forbairt	1,829	4,576	6,524	(119)	
Irma	EU	(7,874)	22		(7,852)	
Irma II	EU		18,787	18,918	(131)	
LDEF	Forbairt	713			713	
Star Formation	EU	5,086	12,267	17,353		
Core Mantle I & II	EU	33,909	72,982	119,195	(12,304)	
Kenya	EU	5,552	6,100	12,051	(399)	
Kenya II	EU	2,532		28	2,504	
BGS II	BGS	(9,737)	10,138	12,532	(12,131)	
Rapids III	Forbairt	16,394		2,818	13,576	
EPAS Plasma	EU	(1,377)	6,084	4,624	83	
Plasma Cooperation	EU		7,679	3,028	4,651	
Jet	Forbairt	15,551	10,000	20,576	4,975	
Slow Evolution	Forbairt	3,150	2,000	5,728	(578)	
Varnet	EU	41,628	412	68,828	(26,788)	
Gloria	Marine Institute	2,938	158,526	135,613	25,851	
Gloria II	Marine Institute	1,000	14,185		15,185	
Cores Nearby Galaxies	EU		6,110	249	5,861	
RAL	R.A.L.		875	875		
High Energy	EU		47,289	32,297	14,992	
Data Reduction	Forbairt		2,700		2,700	
RIFTS	EU		198		198	
Other Fees	Various		1,422	1,422		
		121,427	**460,513**	**527,605**	**54,335**	**54,335**

School of Theoretical Physics

Crossover	EU	(5,509)	26,269	20,760		
CNRS	EU	1,637	2,218		3,855	
Esprit	EU		175,166	167,785	7,381	
RITE	EU			1,790	(1,790)	
Network Rennes	EU	11,520	5,776	1,828	15,468	
		7,648	**209,429**	**192,163**	**24,914**	**24,914**

Net balance unexpended at 31 December 1996 **79,249**

Notes to the Financial Statements

3. Fixed Assets

	Furniture & Equipment	Motor Vehicles	Computers	Total
Cost	£	£	£	£
Opening Balance 1/1/96	701,619	14,711	1,042,073	1,758,403
Additions	189,700		65,656	255,356
	891,319	14,711	1,107,729	2,013,759
Disposals	(5,124)		(5,686)	(10,810)
	886,195	14,711	1,102,043	2,002,949
Depreciation				
Opening Balance 1/1/96	509,291	14,011	699,126	1,222,428
Charge 1996	42,705	200	112,651	155,556
	551,996	14,211	811,777	1,377,984
Depreciation on disposals	(2,504)		(6,274)	(8,778)
	549,492	14,211	805,503	1,369,206
Net book value 31/12/96	336,703	500	296,540	633,743
Net book value 31/12/95	192,328	700	342,947	535,975

The net book value of £633,743 includes an amount of £5,404 in respect of assets held under finance leases

4. Capital Reserve

	1996 £	1995 £
Balance at 1 January	535,975	256,841
Transfer from Income and Expenditure Account		
Income allocated to acquire fixed assets	255,356	387,385
Amortisation in line with asset depreciation	(155,556)	(107,662)
Amount released on disposals	(2,032)	(589)
	97,768	279,134
Balance at 31 December	633,743	535,975

Notes to the Financial Statements

5. Funds

		1996 £	1995 £
These comprise:	Vernam Hull Bequest	33,760	32,269
	Carmody Fund	1,730	1,678
		35,490	33,947

The funds are held on deposit.

6. General Administration Expenses:

	1996 £	1995 £
Rent, Rates & Insurance	96,071	93,561
Premises Maintenance	57,220	96,502
Postage & Telephones	51,873	52,748
Fuel, Light & Power	40,367	37,691
Audit Fee	3,900	3,900
Sundry Supplies	12,056	13,367
	261,487	297,769

7. Leasing

Operating Leases

The premises occupied by the Institute are leased from the Office of Public Works. An additional lease was acquired in 1993 from Findlaters Ltd. for the purpose of book storage. The commitment on foot of such leases in respect of 1997 is £52,316.

Finance Leases

Included in Creditors is an amount of £5,191 liability under a finance lease.
The maturity of the above is as follows:

Under one year	£4,614
In the second to fifth year	£577

8. Miscellaneous Income

Included under this heading is Bank Interest earned of £24,693 (1995 - £20,299) in the year.

9. Superannuation

The total superannuation payments in the year amounted to £315,523 (1995 - £307,508). The salaries and superannuation charge in the accounts is net of contributions totalling £34,052 (1995 - £37,290).

DUBLIN INSTITUTE FOR ADVANCED STUDIES

REPORT OF THE COMPTROLLER AND AUDITOR GENERAL

I have audited the financial statements on pages 2 to 9.

Responsibilities of the Council and of the Comptroller and Auditor General

The accounting responsibilities of the Council of the Institute are set out in the Statement of Responsibilities of the Council on page 1. It is my responsibility, under section 28(3) of the Institute for Advanced Studies Act, 1940 to audit the financial statements presented to me by the Council and to report on them. As the result of my audit I form an independent opinion on the financial statements.

Basis of Opinion

In the exercise of my function as Comptroller and Auditor General, I plan and perform my audit in a way which takes account of the special considerations which attach to State bodies in relation to their management and operation.

An audit includes examination, on a test basis, of evidence relevant to the amounts and disclosures in the financial statements. It also includes an assessment of the significant estimates and judgments made in the preparation of the financial statements, and of whether the accounting policies are appropriate, consistently applied and adequately disclosed.

My audit was conducted in accordance with auditing standards which embrace the standards issued by the Auditing Practices Board and in order to provide sufficient evidence to give reasonable assurance that the financial statements are free from material misstatement whether caused by fraud or other irregularity or error. I obtained all the information and explanations that I required to enable me to fulfil my function as Comptroller and Auditor General and in forming my opinion, I also evaluated the overall adequacy of the presentation of information in the financial statements.

Opinion

In my opinion, proper books of account have been kept by the Council and the financial statements, which are in agreement with them give a true and fair view of the state of the affairs of the Institute at 31 December 1996 and of its income and expenditure and cash flow for the year then ended.

John Purcell
Comptroller and Auditor General
18 May 1998